Conservation Assessment of Steelhead Populations in Oregon

Mark W. Chilcote
Natural Production Section
Fish Division

Oregon Department of Fish and Wildlife
2501 SW First Avenue
Portland, Oregon 97207

March 2001

Table of Contents

Introduction

This report was prepared to accomplish two primary objectives. First, to provide updated information and analyses with respect to the conservation status of wild steelhead populations in Oregon. Secondly, it is intended to provide assistance to fish managers in their evaluation of the impact of steelhead fisheries and hatchery programs on the biological health of this species.

Both objectives have immediate application as ODFW is currently in the process of preparing a variety of management plans under the 4(d) provisions of the Endangered Species Act (ESA) at the request of the National Marine Fisheries Service (NMFS). Although this effort is focused on listed populations in the Columbia Basin, similar ESA issues potentially exist for coastal steelhead populations. For example, as a result of a recent court order, NMFS is once again evaluating steelhead populations of southern Oregon and northern California for possible addition to the threatened species list.

The report is organized by data sets that are thought, in most cases, to represent demographically independent groups of naturally reproducing steelhead following the concepts described by McElhaney et al. (2000). However, one reality of these data sets is that they are not evenly distributed throughout Oregon. Depending on the presumed population structure and interrelationships of these populations, there are invariably natural production units for which data does not exist. As a result, to assess this species it is necessary to utilize a “zone of inference” around each data set. In some cases this zone encompasses only a single population. However, in other situations, it includes multiple populations.

With respect to a status assessment, the construction of these zones of inference has more practical significance than does population and sub-population structure. For example, if the picture from multiple monitoring sites within a given region appears uniformly healthy, then it seems reasonable to conclude that the steelhead within this region are healthy, regardless of which population or sub-population they belong to. However, if the picture is not uniform, then a single regional zone of inference becomes difficult to justify. Indeed, in this latter case the status of steelhead in unmonitored production areas may be impossible to resolve with any certainty. Especially if there is no knowledge as to which population they might demographically cluster with. The conservative approach to such a situation is to assume the status of these unknown populations is bad.

Therefore, the resolution of these zones of inference is the crux in assessing Oregon's steelhead populations. The methodologies used in this report were tailored to address this analytical problem. As a result, they produced an assessment with more emphasis on among population comparisons as opposed to descriptive treatments of individual populations.

Finally, a word about the organization of this report. The results and discussion section covers population and sub-population descriptions, recent trends and abundance, an estimate of critical conservation thresholds for each population with respect to abundance, trends in productivity, a population viability analyses for each population, and a synthesis of these results. In addition, three supplemental sections area also included. The first describes an evaluation of how sensitive the conservation status of each population is to changes that cause an increase in mortality (for example fishing mortality). The second supplemental section examines the potential impact of naturally spawning hatchery fish on the productivity of natural populations. The last section is a brief comparative summary of report findings with particular attention to the zones of inference for which they apply.

Analytical Concepts and Methods

Abundance Estimates

For each monitoring location, annual estimates of adult spawner abundance or density (fish per mile) were determined from direct adult enumeration at counting facilities (Rogue, Umpqua, Clackamas, Sandy, Hood, and Umatilla populations), from redd counts (most other locations), or from mark-recapture population estimate techniques (Deschutes and Walla Walla populations). Conversion of redds per mile to spawners per mile, discrimination between hatchery and wild fish, and estimation of cumulative fishery mortality on wild steelhead was similar to methods described by Chilcote (1998). Estimates of pre-harvest abundance for wild steelhead were obtained by dividing annual estimates of spawner abundance by 1 minus the associated harvest rate.

<u>Productivity</u>

Productivity, as used in this report, is the number of adult offspring (recruits) produced per spawner. It is determined by counting all of the fish that spawn in a monitoring area (both hatchery and wild fish) and dividing this number into the number of pre-harvest offspring produced by these spawners. Steelhead have a complex life history with multiple ages of return and the capacity to spawn more than once. Therefore, estimating recruits is process of apportioning each year's return into the correct parental brood year and then obtaining a brood year total my adding up its apportioned amount across multiple return years.

Productivity, in its various expressions, is probably the most important factor to consider in assessing the conservation status of a species. It is related to the innate ability of a population to rebuild its self and therefore relates directly to forecasting the persistence of the population. In addition, the incorporation of underlying trends or cycles in productivity is often critical in understanding the true biological health of a population. Further, by regressing observed recruits per spawner and total spawner abundance it is possible to estimate the capacity of a given habitat to produce adult steelhead. In other words, it is possible to estimate the number of spawners needed to seed the available habitat to maximum production (maximum seeding).

For most naturally reproducing populations, productivity (recruits per spawner) decreases as the spawner abundance increases. This is because as juveniles fill up the available habitat, the proportion that is able to survive becomes less and less. Therefore, to estimate the productivity of a population in a consistent manner, it is necessary to standardize the recruit per spawner data with respect to spawner abundance. In this report, this standardization process was accomplished by estimating the $\boldsymbol{a}$ parameter of the Ricker recruitment equation,

$$\text{Recruits} = \text{Spawners}(2.718^{(\boldsymbol{a} + \boldsymbol{B}(\text{Spawners}))}) . \qquad \text{Equation 1}$$

In this recruitment relationship both the $\boldsymbol{a}$ and $\boldsymbol{B}$ parameters were estimated using the linear regression method, where the general equation, $y = \boldsymbol{a} + \boldsymbol{B}(x)$, was transformed to:

$$\text{Ln}(\text{Recruits/Spawner}) = \boldsymbol{a} + \boldsymbol{B}(\text{Spawners}) \qquad \text{Equation 2}$$

Therefore, for a data set of paired observations of spawner abundance and Ln(recruits/spawner), the $\boldsymbol{a}$ parameter is the y-intercept and the $\boldsymbol{B}$ parameter the regression line slope, which is almost always negative.

Because these values remain the same for a population, regardless of its spawner abundance, they serve as a standardized way to compare different populations and as a way to compare the same population at different intervals of time. The ***a*** parameter serves as a means to compare population productivity. In addition, the inverse of the ***B*** parameter, 1/***B***, can be shown to be the spawner abundance which generates the maximum number of recruits. Therefore, the ***B*** parameter can be used to estimate how many recruits a population can produce, while the ***a*** parameter estimates how efficient the population is in producing them. For the purposes of this report, 1/***B***, the number of spawners necessary to achieve maximum production of recruits, will be referred to as "maximum seeding ".

Estimates for ***a*** and ***B*** were generated for 27 of the 31 data sets examined. The four data sets omitted were from relatively new monitoring sites and as such did not yet have a sufficient number of data points to estimate their recruitment parameters. Most data sets examined extended back to 1974. Rather than fitting a single recruitment curve to all of the data from each site, a series of multiple curves, and associated estimates of ***a*** and ***B*** were determined for each data set. This was done to examine the temporal variation in productivity.

These multiple curves were build upon a moving 7-year sequence of spawner/recruit data. For example, for a population having spawner/recruit data beginning in 1974, the first recruitment curve was estimated for the spawners of 1974 to 1980 and their subsequent recruits. The next recruitment curve was based upon the production of 1975 to 1981 spawners. The third curve, for 1976 to 1982 spawners and so forth until the end of the data set. Depending on the length of the data set, 10 to 25 recruitment curves and associated values for the Ricker equation parameters ***a*** and ***B*** were generated for each population.

Population Structure

As stated earlier, the majority of the data sets presented in this report were thought to represent demographically independent populations of naturally reproducing steelhead. In general the boundaries for these populations followed those described by Kostow et al. (1995). However, in the interest of meeting the test of demographic independence, steelhead from several smaller populations were lumped together as one. This was done largely on the basis of geographic proximity and relative size of each watershed. Although somewhat logical, the empirical evidence to justify such "lumping" was generally lacking. This is because data is rarely collected from steelhead returning to these smaller basins.

Sub-populations were also identified in this exercise, largely at the suggestion of biologists familiar with the local area. The criteria used for identification of these sub-populations were known discontinuities in hydrology, elevation, geology, temperature regime, vegetative cover, basin aspect, and spawn timing. It was assumed that these physical differences were capable of causing some degree of reproductive isolation and genetic adaptation. In addition, a limited set of biochemical data was used to gauge the level at which divisions likely occurred.

In the case of many populations, especially in the Columbia basin, sufficient data were available to gauge their likelihood of demographic independence. This took the form of comparing trends in abundance, productivity and relative vulnerabilities to extinction.

Conservation Thresholds

To provide better a context for estimates of spawner abundance, two numerical conservation thresholds were developed, "critical" and "viable". These thresholds were intended to be ODFW's interpretation of the critical and viable thresholds described by McElhaney et al. (2000) and NMFS (2000). As used in this report, these thresholds represent one of several biological criteria used to determine the overall status of steelhead populations in Oregon. In addition to these conservation thresholds, natural production benchmarks representing 50% and 100% of maximum seeding were developed.

Several of the populations examined contain naturally spawning hatchery fish. However in determining the conservation thresholds for these populations, the reproductive contribution of these hatchery fish was excluded. This approach was taken to ensure that the conservation thresholds would represent the natural, self-sustaining response of populations to critical levels of abundance in consistent manner. Hatchery fish, when they are present, are sources of reproductive effort whose origins are essentially external to the natural population. Potentially, this can give the illusion that a population is self-sustaining at low levels, when in fact this is not the case. Therefore, hatchery fish were excluded from the conservation threshold estimation procedure in order to achieve a standardized means of describing these thresholds.

The approach for estimating population specific values for the viable threshold and the other 2 natural production benchmarks was largely the same. As discussed previously, multiple recruitment curves were calculated for each population. Each of these curves had an associated value for the $\boldsymbol{B}$ parameter. For each population, these $\boldsymbol{B}$ values were averaged and then divided into 1 to obtain an estimate of the average number of spawners needed to produce maximum recruitment. The natural production benchmarks were calculated as 0.5/***B*** and 1.0/***B***, corresponding with 50% and 100% of the number of spawners necessary for maximum recruitment (maximum seeding).

The viable threshold was set at 20% of the maximum seeding level or 0.20/***B***. The logic for selecting 20% of 1/***B*** as the threshold was based upon the lack of confidence in predicting the response of populations at escapement levels less than this level. The primary reason for this uncertainty was that escapements below these levels have rarely been observed in the data sets. Averaged across all populations and years, only 6% of the spawner escapement data points were less than 0.20/***B***. Therefore, very little information was available to investigate how these populations actually performed at low escapement levels. In light of these shortcomings, it seemed logical that this threshold of uncertainty would suffice as the viable threshold.

To examine the consistency with concepts described by McElaney et al. (2000), viable thresholds for each population were evaluated to determine if they represented the boundary above which the probability of extinction in 100 years was “negligible”. Using criteria presented by Allendorf et al. (1997), extinction risk was considered “negligible” if the probability of population extinction in 100 years was 5% or less. A population viability assessment (PVA) model, described in subsequent sections of this report, was developed and used to make this evaluation.

The critical abundance level for each population was determined directly from the PVA model. In the context of PVA models, Mace and Lande (1991) proposed the following standard for endangerment: a 20% probability of extinction over a period of 10 generations. For the purposes of this report, their classification of “endangerment” was assumed to be synonymous with “critical”. Adopting this standard, the critical abundance threshold was defined as the number of spawners, that if left alone to naturally reproduce for 50 years (approximately 10 generations) would result in the extinction of the population more than 20% of the time. This critical abundance was estimated for each population by seeding each PVA model run with fewer and fewer initial spawners until a 20% extinction probability was achieved.

Assessing the Impact of Hatchery Fish on Natural Production

To varying degrees, hatchery fish were present in nearly half of the populations examined. There are numerous studies suggesting that naturally spawning hatchery fish may be less successful at leaving surviving offspring than are wild fish (Nickelson et al. 1986, Reisenbichler and McIntrye 1977, Chilcote et al. 1986, Leider et al, 1990, and Reisenbichler and Rubin, 1999). However, whether or not these observations apply universally to all naturally spawning hatchery fish under all conditions remains unknown. This question had immediate implications to the assessment of steelhead populations in Oregon. Specifically, for the populations examined, did the productivity of naturally spawning hatchery fish and wild fish differ and by how much? If differences exist, then this element would have to be incorporated into the assessment. Complicating matters further, the past and future presence of hatchery fish in Oregon's steelhead populations is not static. Changes have occurred in the recent past and are expected to occur in the near future.

In light of these considerations, it was necessary to determine the likely impact of hatchery fish on the productivity of these naturally reproducing populations. If following this determination it was found that the impact of hatchery fish could be significant, then there would be a need to add this factor to the assessment protocol. Further, in considering this factor, it would be necessary to incorporate the known dynamic nature of past, present, and future hatchery programs.

To assess the potential impact of hatchery spawners on natural production, overall population productivity was compared to the relative abundance of hatchery and wild fish on the spawning grounds. It was hypothesized that if hatchery fish had an adverse impact on natural production, then populations with high proportions of hatchery fish would be less productive than populations where the proportion of hatchery fish was low.

Values for the Ricker $\boldsymbol{a}$ parameter were used as an index of productivity. As described earlier, multiple recruitment curves, based upon 7-year spawner sequences, were fit to each population's data. This generated a time series of $\boldsymbol{a}$ parameter values for each population. The average proportion of hatchery fish for each 7-year sequence was matched up with the corresponding value estimated for the $\boldsymbol{a}$ parameter. Data from all populations was prepared in this fashion and grouped according to time period, beginning with the 7-year sequence from 1978 to 1984, and ending with the 1989-95 sequence. This resulted in population productivity and hatchery proportion data groups for 12 time intervals.

For a majority of these populations the proportion of hatchery fish was 0.00. However, three of these populations without hatchery fish were included in this evaluation: Joseph, Lower NF John Day, and North Umpqua winter steelhead. The remaining populations used in this analysis all had a history of naturally spawning hatchery spawners.

These included the following populations: Imnaha, Upper Grande Ronde, Umatilla, Deschutes, Sandy, Clackamas, Sandy, Molalla, North Santiam, South Santiam, North Umpqua summer steelhead, Rogue summer steelhead, and Rogue winter steelhead.

For each 7-year time period, a linear regression was performed, with '*x*' being the proportion of hatchery fish and '*y* ' the ***a*** parameter value. Represented by the equation:

$$y = \text{Slope}(x) + \text{Intercept} \qquad \text{Equation 3}$$

If, in reviewing the results of these analyses for the 12 time intervals, regressions were found to be statistically significant and having negative slopes, then it was to be concluded that hatchery fish were less productive than wild fish.

<u>Forecasting Persistence</u>

A key component of this assessment was forecasting the likelihood of extinction for each population under a variety of possible future conditions. The status of populations whose probability of extinction was forecast to be low or non-existent was assumed to be relatively healthy. In contrast, when the probability of extinction was high, the population was assumed to be at risk and unhealthy. To make these forecasts, a population viability assessment (PVA) model was developed. PVA models are frequently used in conservation biology to assess the vulnerability of populations to extinction. Such models have several common elements.

First, to forecast the abundance of a naturally reproducing population at some point in the future (e.g. 100 years) it is necessary to select an expected reproductive rate for this time period. Usually, it is assumed that the reproductive rate in this future period will be similar to the rate observed in the recent past. In the model used here, the reproductive rate that is assumed in the future was not a single number derived from averaging past rates observed for each population in recent years.

To provide a more realistic model of long-term population recruitment, a different rate is selected for each generation of recruits forecast. These reproductive rates are randomly selected from a pool of possible values. This pool of possible values is usually generated on the basis of the variation in reproductive rates observed for each population.

As an outcome of randomly selecting reproductive rates, the population abundance at the end of each cycle of a model run will not be the same.

Therefore, another characteristic of PVAs is that multiple forecasts (usually between 500 and 5000) are made for each set of conditions tested. The number of these forecasts where the population is less than a numerical threshold are then counted and divided by the total number of forecasts made. The result is an estimate of the probability that a population will be less than a numerical threshold within the test period. Often the numerical threshold is set at zero, or extinction. Therefore, the results of a PVA are usually stated in terms of the probability of extinction at some future point in time.

Finally, the interpretation of these PVA results requires a consistent standard for how much risk is acceptable. For example, a commonly used standard is that a population is endangered if the probability of extinction is greater than 20% at a point in time 10 generations into the future (Mace and Lande, 1991). Likewise, if a population has a probability of extinction of 5% or greater after 100 years, then it commonly would qualify for a threatened classification (Allendorf et al. 1997 and Thompson, 1991).

The specifics for the PVA used to evaluate the steelhead populations considered in this review were as follows. The natural spawning abundance (or density) of hatchery plus wild fish for the most recent 6 years (1995 to 2000) were used to seed each PVA model run. Once seeded, the recruits from this escapement were forecast, subjected to a hypothetical fishery and then converted to spawners from whom the next generation of recruits was forecast. This process was repeated until a period of either 50 or 104 years had passed. Upon completion, the number of spawners in the last 6 years of the forecast period was examined to determine if they had declined to the zero. If zeros were forecast for all six ending years, then the cycle was recorded as an extinction event. Once completed, a second cycle was started using the same number of initial spawners and model conditions. The same forecasting process was run forward for the same length of time. If a second extinction event occurred it also was recorded. A single model run consisted of 1000 of these repeated cycles. The probability of extinction was calculated by dividing the number of cycles that resulted in an extinction event, by 1,000, the total number of cycles for each model run.

In addition to model runs to estimate the probability of extinction, the PVA model was also used to estimate the probability that a population would decline to levels below its viability abundance threshold. In this case, if the forecast abundance of the population were less than the viable threshold in the last 6 years of the model run, then this would be recorded as a “viability risk event”.

To estimate the number of recruits within each iteration of the model run it was necessary to develop a method to randomly sample reproductive rates from a pool of values that could be reasonably expected to occur in the future. It was assumed that the magnitude and pattern of reproductive rates observed for these populations over the last 25 to 30 years could be used to approximate future reproductive rates. Obviously, this assumption could not be tested directly. Of special concern is the possibility that future reproductive rates will be less than those of the past. If this were to occur, the PVA results would overestimate the likely persistence of these populations. Therefore, to reduce the risk of over-estimating persistence, the average survival of rates used in the model runs were 30% from what had actually been observed in the recent past.

The multiple recruitment curves fit for each population formed the basis from which the future reproductive rates were determined. As discussed earlier these curves were based upon a moving, 7-year sequence of spawner and recruit data. Each time period was assigned to a code year. The code year was the mid-point of the brood year sequence from which each recruitment curve was generated. For example, the code year 1972 represented the recruitment function for the fish that spawned from 1969 to 1975. Code year 1973 indexed the recruitment function for fish from 1970 to 1976. Associated with each code year was a value for the $\boldsymbol{a}$ and $\boldsymbol{B}$ recruitment curve parameters.

A preliminary examination of the $\boldsymbol{a}$ parameter values for the code years from 1972 to 1993, suggested that cyclic pattern existed for most steelhead populations. It appeared that a peak in $\boldsymbol{a}$ values occurred with the code year 1981, followed by a low point in $\boldsymbol{a}$ values with the 1990 code year, a time frame of 9 years. Further, that 9 years prior to the peak in 1981, there appeared an earlier low point corresponding with the 1972 code year. This pattern suggested a symmetrical fluctuation of $\boldsymbol{a}$ parameter values, having a period of approximately 18 years. It was hypothesized that this cyclic pattern was a reasonable model for what would occur in future years. Therefore, this cycle was extended forward to the code year 2120. For each population, observed $\boldsymbol{a}$ and $\boldsymbol{B}$ values for code years 1972 to 1992 were repeated in reverse and then forward sequences such that they tracked the assumed cycle from code year 1994 to 2120. These “dummy data” were the basis from which the reproductive rates used in the PVA model were drawn.

As each cycle of the model run proceeded, the number of recruits would be calculated for each code year and then these recruits assigned to different future years of adult return depending on the average age distribution of the population. For example, if the recruitment from spawners in 2030 was 1,000 fish and the average age distribution was

10% age 3, 60% age 4, and 30% age 5, then 100 fish would be assigned to the pool of potential spawners of 2033, 600 to the year 2034, and 300 fish to the year 2035. The spawner code year would then be advanced one to the year 2031 and a new set of recruits produced and distributed to the appropriate future brood years. In this way, the number of spawners was build up for each future generation in the model. Obviously, when a fishery mortality rate was imposed, there was an intermediate step of removing some the recruits before they could be classified as spawners.

However, estimating the recruits from any one code year of spawners was not a simple deterministic process of using the Ricker recruitment formula with the specific values for $\boldsymbol{a}$ and $\boldsymbol{B}$ assigned to each code year. To introduce randomness into the process, the $\boldsymbol{a}$ and $\boldsymbol{B}$ values were drawn from a 7-year sequence of code years that included the reference code year as its midpoint. For example, for estimating recruitment for the fish that spawned in 2023, a code year from 2020 to 2026 was randomly selected. Once selected, the associated values for the $\boldsymbol{a}$ and $\boldsymbol{B}$ parameters were used in the Ricker function from which the recruits for the 2023 brood year were calculated. The decision to use a sequence of 7 years to randomly draw the recruitment parameters for the each calculation was a compromise. In picking a time interval for this purpose, it was necessary to have enough data points to ensure that a reasonable degree of randomness would be introduced into the PVA model. However, this had to be balanced with not having so many data points that the cyclic nature of the underlying reproduction rate would be homogenized. For example if the recruitment parameters were drawn randomly from an 18-year sequence of code years, the cyclic pattern (which appears to have a period of 18 years) would be effectively lost from the PVA simulation.

There were four additional, yet significant, nuances placed upon the process of forecasting recruits within the PVA model. First, as noted earlier, it was unknown if the relative survival rates observed over the last 20 to 30 years would be the similar to those of the future. It is possible that these future rates will be lower. Persistence forecasts based on higher than realized reproductive rates will yield extinction risks that are too low. Therefore, in order to make this outcome less likely, the survival rates for all model runs were assumed to be 30% less than those actually observed in the last 30 years. To make this adjustment, the number of recruits calculated each time the Ricker recruitment function was used within the model was reduced by 30%.

The second nuance dealt with forecasting recruits when the number of spawners was very large. The nature of the Ricker recruitment function is such that once spawner escapements exceed $1/\boldsymbol{B}$, the level necessary for maximum recruitment, the number recruits begins to decline. In some cases this rate of decrease may be quite rapid. Although, the number of populations for which spawner escapements in this upper range have been observed is limited, a preliminary assessment of their subsequent recruitment did not appear consistent with a recruitment function that had a strongly declining right-hand limb. Indeed, alternate recruitment functions that do not have this decreasing recruitment behavior at high escapement levels, such as the Beverton-Holt equation, are often used for species like steelhead (Burgman, et al. 1993). However, the Beverton-Holt model was not used in the present population assessment for a variety of reasons. The primary reason being that the purpose of this assessment was to determine the risk of extinction for these populations. Therefore, the portion of the recruitment function that was of greatest importance was the performance at spawner densities considerably less than $1/\boldsymbol{B}$. In this range the Ricker function appears to provide as good, if not better, fit to the pattern of recruitment in steelhead than the Beverton-Holt model.

However, to use the Ricker equation for the PVA model, a modification was necessary in order to get around the inherent problems when spawner density was high. To prevent the tendency for the Ricker function to underestimate recruits at these high spawner densities, a conditional step was added to the recruitment forecast process. This conditional step was triggered when the simulation model produced a number of spawners greater than $1/\boldsymbol{B}$. Under this circumstance the program reset the number of spawners to $1/\boldsymbol{B}$. This step essentially meant that for any spawner escapements greater than necessary for maximum production, the recruits would be equal to maximum production. This eliminated the descending right-hand limb of the Ricker recruitment function, which for steelhead was felt to be problematical.

Another feature added to the recruit forecasting process was a modification to the model when spawner densities were very low. The available data sets contained only a few points from extremely low escapement levels. Therefore, it was not clear how the recruitment process actually functioned at these low levels. As noted earlier, this sense of uncertainty lead to the designation of a viable population threshold for spawner levels less than 20% of $1/\boldsymbol{B}$. For spawner escapements less than 0.20/B, it was difficult to confirm that the Ricker function was a good representation of the recruitment process. Of particular concern was the chance that at these low levels the expected recruitment mechanisms may begin to fail (Glipin and Soule, 1986). Either because of genetic problems or the inability of spawners to find mates in a low-density environment, the productive capacity of a population may decrease as the population declines below some critical level of spawners. If such factors come into play for depressed steelhead populations, then using an unmodified Ricker model to forecast recruitment would overestimate a population's resiliency and productivity. This could lead to overly optimistic conclusions about the resistance of the population to extinction. Since there was a strong desire to avoid this type of error, the recruitment function was modified to be less productive at low spawner densities. Although there was no empirical evidence from which to base this modification, it was added because from a conservation management standpoint, the consequences of overestimating the probability of extinction were more acceptable than those associated with underestimating the probability of extinction.

The specific depensation modification to the recruitment function at low spawner densities was as follows. First, it was assumed that for spawner densities less than 0.04/***B***, the population was essentially extinct and so the number of recruits produced from escapements less than 0.04/***B*** was set to equal zero. For spawner densities in the range from 0.04/***B*** to 0.20/***B***, the recruitment function was a simple linear relationship beginning with zero recruits when spawner density was 0.04/***B***, and increasing proportionately to the number of recruits forecast by the Ricker function when the spawner levels was 0.20/***B***. For example, suppose for a particular population the levels of 0.04/B and 0.20/B were estimated to be 60 and 300 spawners, respectively. Using this approach, the number recruits from an escapement of 60 fish would be set at zero. The number of recruits from an escapement of 300 spawners, as predicted by the Ricker recruitment function would be suppose 600 fish. Therefore, the recruitment from an intermediate escapement, suppose 90 fish, would be calculated as: 600[(90-60/(300-60)] = 600(0.125) = 75 recruits.

Lastly, and the most complicated addition to the recruitment forecasting process was the mechanism devised to account for differences in reproductive success between naturally spawning hatchery and wild fish. As discussed earlier, studies have shown that at least in some situations, the reproductive success of naturally spawning hatchery fish is much less than it is for wild fish. Further, methods were also described earlier to determine if evidence for this difference existed for the steelhead populations examined by this assessment. Because, it was thought likely that such differences would be found, an approach for making adjustments to the recruitment forecasting process of the PVA model was developed.

Obviously, for populations that have never been exposed to hatchery fish and were assumed to remain in this condition for the future, no adjustments were necessary. In particular, the reproductive rates for the base period (1972 to 1992 code years) could be projected forward into future without modification. Likewise, adjustments were not necessary for populations in which the proportion of hatchery fish had remained relatively stable through the base period and was expected to remain unchanged in the future.

However, the populations that were a potential problem were those for which had considerable fluctuation in the proportion of hatchery spawners during the base period and for which it was also unlikely this pattern would be repeated in the future. Also a problem, were those populations for which the average proportion of hatchery spawners in the future was expected to differ from the proportion during the base line time period. For example, if the proportion of hatchery fish in the base period was in the range of 30 to 50%, but was expected to decline to 10% in the future, then using the reproductive rates observed during the base period to forecast the recruitment in future years would underestimate the productivity of the population and its resistance to extinction. (Obviously, this problem would only exist if a difference in productivity between hatchery and wild fish belonging to the populations evaluated in this assessment were confirmed). Likewise, the future productivity and resistance to extinction would be overestimated for a population that had very few hatchery fish during the base period, but was expected to have a much higher proportion in the future. The approach for correcting these potential sources of error was as follows. First, the theoretical relationship between the overall productivity of a population and the proportion of hatchery fish in the population was represented by:

$$\boldsymbol{a} = P_w(\boldsymbol{a}_{wild}) + P_h(\boldsymbol{a}_{hatchery}) \qquad \text{Equation 4}$$

where $\boldsymbol{a}$ is the Ricker recruitment parameter calculated for the population at a particular time interval, P_w and P_h are the respective proportions of wild and hatchery fish in the natural spawning population, $\boldsymbol{a}_{wild}$ is the recruitment parameter that would have been estimated for this population were the only spawners wild fish, and $\boldsymbol{a}_{hatchery}$ the recruitment parameter for a spawning population consisting only of hatchery fish.

If the values for $\boldsymbol{a}_{wild}$ and $\boldsymbol{a}_{hatchery}$ and the future proportion of hatchery spawners could be known then the overall productivity of the population, $\boldsymbol{a}$, could be calculated. The past and present proportion of hatchery fish can be resolved with relative ease. However, the sequence of $\boldsymbol{a}$ values for the base period (1972 to 1992 code years), are overall measurements and do not contain separate estimates for $\boldsymbol{a}_{wild}$ and $\boldsymbol{a}_{hatchery}$. Therefore, a method was needed to estimate $\boldsymbol{a}_{wild}$ and $\boldsymbol{a}_{hatchery}$ for the base period so that these values could be used to compute a more realistic overall population value for $\boldsymbol{a}$ in future years under scenarios where the proportion of hatchery fish was expected to change. Equation 4, discussed previously, provides a means to do this.

To evaluate the potential for a relationship between the proportion of hatchery fish and overall population productivity, a linear equation was fit to the paired data sets from 15 steelhead populations for each of 12 time periods evaluated (code years 1981 to 1992) (see the methods section "Assessing the Impact of Hatchery Fish on Natural Production"). Slope and intercept parameters for a linear regression was estimated for each of the 12 time periods. Based upon each regression equation, theoretical $\boldsymbol{a}$ values for a population comprised entirely of wild fish and a second hypothetical population comprised entirely of hatchery fish were calculated (i.e., x in the regression equation was set to 1.0 to obtain the upper range limit for $\boldsymbol{a}$ and set to 0.0 to obtain lower range limit for $\boldsymbol{a}$). This calculation was made for all 12 regressions and resulted in theoretical $\boldsymbol{a}$ values for a population comprised of 100% wild fish and one comprised of 100% hatchery fish for each of the time intervals corresponding to code years 1981 through 1992.

For the purposes of the PVA, this generalized model for assessing differences between hatchery and wild fish in terms of productivity had to be further modified so that it was specific to each population. This was accomplished in the following manner. First, the average proportion of hatchery fish for each population for each code year from 1981 to 1992 was calculated. Recall, that the estimates of $\boldsymbol{a}$ and $\boldsymbol{B}$ for each code year correspond with the recruitment from 7 brood years of spawners. Therefore, 7 years of data were used to compute each average.

Average hatchery fish proportions were then substituted into the generalized hatchery-wild regression models corresponding with the same time interval and an expected overall $\boldsymbol{a}$ value was calculated. For example, if the observed average proportion of hatchery fish for code year 1985 was 0.30, then this value would be substituted for x in the generalized regression equation corresponding to the code year 1985 (i.e., 1982 to 1988 brood years). This step yielded an expected overall population value for productivity, $\boldsymbol{a}_{\text{exp}}$. This expected value was compared to the $\boldsymbol{a}$ value actually calculated for the specific population and used to standardize the estimates of productivity for wild fish and hatchery fish as shown in Equations 5 and 6.

$$\boldsymbol{a}_{\text{pop\_wild}} = \boldsymbol{a}_{\text{wild}} + (\boldsymbol{a}_{\text{obs}} - \boldsymbol{a}_{\text{exp}}) \qquad \text{Equation 5}$$

and $$\boldsymbol{a}_{\text{pop\_hatchery}} = \boldsymbol{a}_{\text{hatchery}} + (\boldsymbol{a}_{\text{obs}} - \boldsymbol{a}_{\text{exp}}) \qquad \text{Equation 6}$$

Where $\boldsymbol{a}_{\text{pop\_wild}}$ is a standardized estimate of productivity for the wild fish that spawned in this specific population during a specific time interval;

a_{wild} is the estimated productivity for the same time interval based upon the generalized model for differences between hatchery and wild fish developed from regression analysis of 15 populations as described earlier; a_{obs} is overall population productivity actually observed for the population during this specific time interval: and a_{exp} is the expected overall population productivity for this time interval as estimated from the generalized hatchery-wild regression model. The terms in Equation 6 are similar to Equation 5, except that in the case of the former they refer to hatchery fish.

Once population specific estimates for a_{pop_wild} and $a_{pop\_hatchery}$ were obtained for all years in the base period, they were expanded to the future code years (1995 to 2120). This expansion was done by repeating the sequence of values for the base period in reverse and forward order as necessary to follow the presumed 18-year productivity cycle.

Once this “dummy data” had been entered, the simulated recruitment for each code year of the PVA model run cycle was estimated using the Ricker recruitment function as previously explained. The primary difference being that the value for the a parameter used in this recruitment calculation was determined from Equation 4. This determination used the a_{pop_wild} and $a_{pop\_hatchery}$ values assigned to each code year and the expected proportion of hatchery and wild fish. It should be noted that in most cases, the proportion of hatchery fish for the model run (expectations for future years) was different from the proportion of hatchery fish observed during the base period (code years 1972 to 1992).

The approach used to model the impact of naturally spawning hatchery fish had several key assumptions. First, when the model runs were set up, the proportion of hatchery fish into the future was fixed. The model treated this situation by adding hatchery fish to each future spawning population relative to the number of wild spawners forecast. For example, if model was set to run with a hatchery proportion of 0.33, a forecast wild spawner escapement of 400 fish was matched with a hatchery escapement of 200 fish. If the wild escapement were 100 fish, it would be matched with a hatchery escapement of only 50 fish.

Although this approach accommodated the reproductive contribution of hatchery fish to natural production, it is an oversimplification of what most likely would occur under a real management situation. Although the number of hatchery and wild fish returning to a basin tend to share the same pattern of annual fluctuations in abundance, this relationship can be dramatically shifted if the number of hatchery smolts released is suddenly increased or decreased. Further, during periods when the natural system is producing fewer wild smolts, either because of habitat problems or lack of escapement, the production of hatchery smolts usually remains constant. Uncorrected, this would result in a higher proportion of hatchery fish on the spawning grounds. Potentially this change would decrease the overall productivity of the population and make it more vulnerable to extinction. However, if the production of hatchery fish remains constant and a portion of them spawn in the wild, it will be theoretically impossible for the natural produced fish to disappear from the basin. As long as the hatchery program continues, there will be at least some natural recruitment. However, such a population would be entirely artificial and therefore not be consistent with the conservation of native species.

Two other issues also need qualification with respect to hatchery fish in the present form of the PVA model. Hatchery fish may be from “wild-type” broodstocks derived from local wild populations or they may be from a more “traditional-type” broodstock, typically derived from non-local populations and often domesticated to a certain degree. While “wild-type” hatchery fish are more likely to be genetically similar to the local wild fish than are “traditional-type” hatchery fish, there is not strong evidence that their relative reproductive capacity in the natural environment differs (Chilcote, 1998). Therefore, for the purposes of estimating natural production within the PVA model, all hatchery fish, regardless of origin, were assumed to equally capable. Information is presented later in the report that examines this assumption in more detail.

The other issue concerns what happens to the productivity of a population of mixed hatchery and wild fish when management changes are made that eliminate or greatly reduce the number of hatchery spawners. The PVA model makes adjustments in productivity under the assumption that any negative impact of hatchery fish on the overall productivity of the wild population is not permanent. It is supposed that any long-term genetic changes that have occurred in the wild population as a result of naturally spawning hatchery fish are relatively minor and will not suppress the innate productivity of the wild population.

There are several pieces of evidence that support this view. First, in those studies where it has been possible to directly measure the reproductive success of naturally spawning hatchery fish and wild fish (Chilcote et al 1986, Leider et al, 1990, and P. Hulett , personal communication), large differences between hatchery and wild fish have been found. In these particular studies, conducted on the Kalama River in Washington, wild fish retained more than a 10-fold advantage in their productivity even though hatchery fish have been present and naturally spawning for over 20 years within the study area. Presumably if genetic damage had been taking place the accumulative effect would have reduced that productivity of the wild spawners and the measured difference in the reproductive success between hatchery and wild fish would have been less. Consistent with this assessment are recent findings by Sharpe et al. (2000). They found biochemical evidence that wild steelhead from the Kalama River had retained a genetically distinctive identity in a comparison with the stock of hatchery fish that has been present in the Kalama basin in high numbers since the early 1970s.

Secondly, previous findings reported by Chilcote (1998) suggest that the productivity of mixed wild and hatchery populations are not particularly sensitive to the type of hatchery broodstock involved in the mix. Hatchery broodstocks from non-local, domesticated origin seem to cause a decrease in overall natural production no greater than do stocks from a local "wild-type" origin. If naturally spawning hatchery fish were causing long-term genetic damage to the wild population, it would seem that the relative greater damage from genetically dissimilar domesticated hatchery stocks versus a "wild-type" stock would be readily evident. However, this does not seem to be the case.

Finally, some hatchery programs in Oregon have been in existence for a long time and others for a relatively short time. For example, hatchery summer steelhead have been returning to the N. Umpqua since 1960 while for the Umatilla hatchery fish have been present only since 1988. If genetic damage was occurring to the wild population, it could be surmised that the longer the exposure to hatchery fish, the more adverse genetic characteristics would have accumulated. However as the results from this assessment will show, the relative productivity of mixed wild and hatchery populations does not appear to very sensitive to the length of time the mixing has taken place.

Therefore, when the available evidence is considered, it seemed reasonable to assume that once hatchery fish are removed from a natural spawning population, its productivity will increase.

The PVA model was used for several purposes, primary among these was to determine, for each population, if the criteria were met for any of the three conservation status designations, endangered, threatened, or viable. The criteria used in this report are as follows:

Endangered – Greater than 20% probability of extinction in 50 years.

Threatened – Greater than a 5% probability of extinction in 104 years.

Viable – Less than 5% probability of declining below the viable abundance threshold (0.20/***B***) in 104 years.

It should be noted the rationale for modeling a period of 104 years instead of the more “traditional” 100-year time frame had to do with the periodicity of the survival cycle imposed by the model. To make the persistence forecasting more conservative, model runs were set up to end at the low point in the survival cycle. The 50-year time period accomplished this. However, to end at the same point on the survival cycle for the longer model runs it was necessary to extend their length from 100 to 104 years.

The assumed fishing mortality rate for all persistence modeling was 5% for coastal populations and the Columbia basin populations downstream from Bonneville dam. For Columbia basin populations upstream of Bonneville dam the adult mortality rate was set at 15%. These numbers reflect the situation that there is nearly a statewide regulation against the killing of wild steelhead. When wild fish are caught, they must be released back to the river. The 5% mortality rate assigned to these populations represents the mortality of wild fish that are caught and then die as results of handling and stress. Populations of steelhead that pass Bonneville Dam enter a non-selective gillnet fishery that causes an increased level of mortality on wild fish. Therefore, a 15% rather than a 5% mortality rate was used to model these populations.

Assessment Results and Discussion

<u>Populations and Sub-populations</u>

The data sets evaluated in this report were assembled into 31 groupings assumed to have some degree of demographic independence and therefore meeting the definition of population as proposed by McElhaney (2000). Population boundaries for Columbia Basin steelhead were comprehensively reviewed as the first step in performing this population assessment. A similar review was not done for coastal steelhead for two practical reasons. For those few locations on the coast where long-term data sets are available, the population boundaries seem relatively obvious and easy to justify as discrete, demographically independent units. The questionable population boundaries on the coast, however, are associated with basins where there is no or very little data. Because of this lack of information, doing an assessment for such populations, regardless of their assumed boundaries, was not possible. Therefore, the review of populations boundaries for such areas is lower priority and will be deferred until the necessary data becomes available in the future.

For the Columbia basin, where the data sets were more comprehensive, a total of 29 populations were identified. Six populations were identified for the Lower Columbia ESU, 6 for the Willamette ESU, 11 for the Middle Columbia, and 6 for the Snake (Appendix 1). In addition, significant sub-population structure within several of the populations was believed to exist, particularly within the Snake ESU. Population and sub-population boundaries were based upon basin size and known discontinuities in hydrology, elevation, geology, temperature regime, vegetative cover, aspect, and spawn timing. It was assumed that these physical differences were capable of causing some degree of isolation, and genetic adaptation. In addition, a limited set of biochemical data was used to gauge the level at which sub-division among populations and sub-populations likely occurred.

Using the temporal pattern of Ricker ***a***-values calculated from moving 7-year sequences of spawner-recruit data, an attempt was made to compare geographically proximate populations for evidence of demographic independence. It was assumed that one indicator of demographic independence might be dissimilar temporal patterns in population productivity. Within the Rogue basin the four populations could be classified as belonging to one of two very distinct patterns. The winter and summer steelhead populations upstream of Gold Ray dam were very similar, with a peak in productivity followed by a significant decline (Figure 1). The winter steelhead population in the Applegate and the summer steelhead population in mid Rogue followed a pattern that was nearly the inverse of the populations above Gold Ray. However, since winter and summer steelhead are assumed to be largely reproductively independent, the evidence from Rogue basin suggests that all 4 populations, either because of their life history or temporal pattern of productivity can be confidently classified as independent from each other.

The pattern for populations in the upper Willamette ESU is less clear. However, it appears that some populations like the Molalla and the Calapooia have experienced relatively wide swings in productivity over the recent past (Figure 2). In contrast, the productivity of upper South Santiam steelhead has remained relatively stable with the exception of a rapid upswing in the last several years. The lower South Santiam seems to have more similarity to the North Santiam population than it does to the steelhead in the upper South Santiam. The pattern of productivity does not support lumping the upper and lower South Santiam together as one population.

Within the Deschutes basin, the decline in productivity experienced by the Warm Springs basin steelhead in recent years was much less than the sudden, and very large decline in productivity for steelhead monitored on the mainstem Deschutes at Sherars Falls (Figure 3). One likely, explanation of this difference is the relatively high incidence of hatchery fish in the Deschutes basin in recent years compared to the Warm Springs system where only wild fish are allowed into the basin.

Six populations were identified for the John Day basin. The temporal pattern of productivity among these populations appears strikingly similar during the middle portion of the observed time series, with the exception of steelhead from the upper North Fork John Day (Figure 4). This population did not show the same decline experienced by populations in the rest of the basin. Because of this difference, it seems reasonable to treat this group of fish as a population separate from those in the nearby lower North Fork or Middle Fork John Day. The productivity of steelhead in the Middle Fork, South Fork and upper mainstem seemed to track quite closely, while steelhead from the lower mainstem and the lower North Fork were different in their productivity during the beginning of the time series. From the standpoint of similar trends in productivity and geographically proximity, if any of these populations should be lumped it would be upper mainstem and the South Fork. However, arguing against such a recommendation is biochemical evidence that suggests that steelhead in the South Fork are genetically distinct within the John Day basin (Kostow, 1995). Therefore, it was concluded that the boundaries for the populations in the John Day should remain as they are described in this report (Appendix 1).

Although 4 populations were provisionally identified within the Grande Ronde basin, data were available from only 3 locations. The productivity of steelhead in the middle mainstem section (Phillips Creek index site) had quite high productivity during the first part to the time series however, by the end of the time series had declined to nearly the same low productivity as steelhead from the upper Grande Ronde (Figure 5). Although the Joseph population experienced a moderate decline towards the end of the time series, the inception of this decline seemed to lag several years behind productivity decline observed for the other the Grande Ronde populations. The magnitude and pattern of productivity among these three groups of steelhead appears as great, if not greater, than for groups of fish that were classified as separate populations in the John Day basin. Therefore, it was concluded the steelhead from the middle Grande Ronde section should not be lumped into the same population as those from the upper Grand Ronde. The geographically logical alternative would be to assign the middle mainstem group to the lower Grande Ronde population. This would result in the moving of the lower Grande Ronde population upstream to encompass the Lookingglass and middle mainstem sub-populations.

Population Trends

The trend in annual pre-harvest abundance of wild fish was examined for 31 populations. In some cases, such as the Hood River and Walla Walla populations, the time series was too short for meaningful evaluation. However, for most populations it was possible to look at the pattern of wild fish abundance for the last 20 to 30 years. Nearly all populations had a rapid decline in abundance during the early to mid 1990s and a low point in abundance during the late 1990s (Appendix 2). However, beyond this shared characteristic there appeared to be 3 semi-distinct temporal patterns of steelhead abundance. By far the most common pattern (Type 1) is characterized by a period of low abundance, followed by a period of greater abundance, and then most recently a second, but more severe low period. To varying degrees all of the populations in the Middle Columbia appear to display this pattern. This pattern also appears to be weakly displayed by several of the coastal populations including the Salmonberry and the upper Rogue summer-run. The second pattern observed (Type 2) seems to be predominating in the Snake ESU. The Type 2 pattern is similar to the Type 1, however in the case of the Type 2 the first period of low abundance is deeper than the second low abundance period. A third pattern (Type 3) was also recognized. It was characterized by a steady decline with no peak in abundance or evidence of cyclic character. This pattern appears most commonly for steelhead populations in the Upper Willamette and Lower Columbia ESUs. Finally 3 populations did not appear to follow any of these patterns. Two populations, winter steelhead in the North Umpqua and upper Rogue displayed a similar cyclic abundance pattern, with no overall trend up or down (Appendix 2). They appeared relatively stable. The Applegate population appeared unique in that it remained relatively stable during the early 1990s, unlike nearly every other population that showed a declined during this period. In addition, the overall trend for the Applegate population appears to upward.

Observed Abundance and Conservation Thresholds

As described in the methods section, critical and viable abundance thresholds were determined for those populations with sufficient abundance data to perform a PVA analyses. Twenty-seven populations met this requirement. In comparing the observed average abundance of wild fish for these populations over the last 6 years, all were greater than the thresholds for critical and viable (Table 1). Indeed, 7 populations appeared to be at abundance levels greater than needed for maximum production of recruits, (i.e., maximum seeding). These included 4 coastal populations (Rogue winter-run, Applegate, N. Umpqua summer-run, and N. Umpqua winter-run), one from the mid-Columbia, the upper N. Fork John Day, and 2 Snake basin populations, Joseph and the lower Grande Ronde. Of the remaining populations, 9 had abundance numbers in the range of 100% to 50% of maximum seeding, while 11 were in the range between 50% of maximum seeding and the viable threshold.

Table 1. Observed 6-year average wild steelhead abundance and conservation abundance thresholds, for 27 populations of wild steelhead in Oregon. Abundance expressed as either total spawners (data without decimal points) or as spawners per stream mile (data with decimal points).

Population	Maximum seeding	50% Seeding	Viable Threshold	Critical Threshold	Recent 6-yr Average
Upper Rogue SR	4485	2242	897	275	3142
Upper Rogue WR	4343	2172	869	247	7352
Mid Rogue SR	47.1	23.5	9.4	6.3	17.6
Applegate WR	1048	524	210	63	1371
N. Umpqua SR	3233	1617	647	189	3546
N. Umpqua WR	4273	2137	855	234	6692
Salmonberry	7.2	3.6	1.4	0.5	4.8
Sandy	1677	839	336	82	651
Clackamas	1396	698	279	73	395
Molalla	49.8	24.9	9.9	2.6	14.0
N. Santiam	83.9	41.5	16.6	13.0	21.9
Lower S. Santiam	41.3	20.6	8.1	2.1	8.4
Upper S. Santiam	524	262	108	33	312
Calapooia	11.3	5.6	2.2	0.8	8.3
Deschutes	7394	3697	1149	398	1997
Warm Springs	399	199	80	32	162
Lower John Day	3.9	2.0	0.79	0.2	2.68
Lower NFk John Day	4.3	2.2	0.9	0.2	2.62
Upper NFk John Day	2.3	1.1	0.5	0.1	3.0
Middle Fork John Day	11.2	5.6	2.2	0.8	4.8
South Fork John Day	8.4	4.2	1.7	0.5	2.6
Upper John Day	7.7	3.9	1.5	0.5	2.6
Umatilla	1666	833	333	103	1247
Joseph	3.4	1.7	0.7	0.2	4.6
Lower Grande Ronde	2.2	1.1	0.8	0.3	2.2
Upper Grande Ronde	3.9	1.9	0.5	0.1	3.3
Imnaha	6.0	3.0	1.2	0.4	4.7

Trends in Productivity

A temporal series of Ricker ***a*** parameter estimates were obtained for each population (see methods section). These are presented for all populations in Appendix 3. It was assumed that the pattern of these ***a*** parameters related directly to the pattern of productivity and recruitment for each population over time. Although there were considerable differences among populations (Figures 1, 2, 3, 4 and 5), the overall pattern suggested the existence of cyclic phenomenon with respect to recruitment. As shown in Figure 6, it appeared that a negative slope cycle, with period of approximately 18 years, explained much of the observed annual variation in the recruitment performance of these populations. As might be expected, this pattern in recruitment is similar to the pattern of pre-harvest abundance for many populations.

Although annual variations in the freshwater environment have been shown to influence the long-term recruitment pattern in steelhead in northern British Columbia (Smith, 2000), it is unlikely that this is the primary controlling factor for Oregon populations. Ecological fluctuations in the marine environment that effect steelhead survival seems to be the best explanation. The observed cyclic pattern of productivity holds for Oregon steelhead from a wide range of geographically distinct and variable freshwater habitats. If variations in the freshwater environment were the primary controlling factor, the heterogeneous nature of these habitats across Oregon would not lead to a nearly universal pattern of fluctuating productivity. Smith and Ward (2000) and Welch et al. (2000) both present evidence that marine survival conditions can be a major factor in controlling the recruitment of steelhead.

Given the apparent importance of this single factor, it is clear that population assessments that do not incorporate the natural cyclic variability in the quality of the marine environment for steelhead will yield potentially erroneous results. This was one of the reasons the PVA model used in this assessment was structured around an assumed cyclic pattern of marine survivals. The sequence of Ricker ***a*** parameters estimated for the multiple 7-year data sets for each population was used as a means to approximate this cyclic phenomenon.

Population Viability Analysis

In examining the PVA results, only the Deschutes and North Santiam populations were found to have probabilities of extinction high enough to trigger the criteria for the classification for endangered (Table 2). Four of the 27 populations, including the North Santiam and Deschutes, met the criteria for threatened. These same 4 populations (Middle Rogue summer-run, N. Santiam, Deschutes, and Umatilla) did not meet the criteria for viable. All had a 5% or greater probability that at the end of the next 104 years their abundance level would be less than the viable threshold (0.20/***B***). However, the remaining 22 populations examined all appear at relatively low risk and have greater than 95% chance of remaining above their respective viable threshold levels. It should be emphasized that these findings are based upon two key assumptions concerning the future productivity of the 27 populations modeled.

Table 2. The probability of extinction and the probability of an abundance less than the viable threshold for 27 populations of steelhead in Oregon with respect to criteria for the classification of endangered, threatened, and viable as determined from PVA modeling.

Population	**Viable**	**Threatened**	**Endangered**
Upper Rogue SR	0.00	0.00	0.00
Upper Rogue WR	0.00	0.00	0.00
Mid Rogue SR	**0.28**	**0.19**	0.00
Applegate WR	0.00	0.00	0.00
N. Umpqua SR	0.00	0.00	0.00
N. Umpqua WR	0.00	0.00	0.00
Salmonberry	0.00	0.00	0.00
Sandy	0.00	0.00	0.00
Clackamas	0.00	0.00	0.00
Molalla	0.00	0.00	0.00
N. Santiam	**0.78**	**0.63**	0.13
Lower S. Santiam	0.00	0.00	0.00
Upper S. Santiam	0.00	0.00	0.00
Calapooia	0.00	0.00	0.00
Deschutes	**1.00**	**0.99**	**0.85**
Warm Springs	0.01	0.00	0.00
Lower John Day	0.00	0.00	0.00
Lower NFk John Day	0.00	0.00	0.00
Upper NFk John Day	0.00	0.00	0.00
Middle Fork John Day	0.00	0.00	0.00
South Fork John Day	0.00	0.00	0.00
Upper John Day	0.00	0.00	0.00
Umatilla	**1.00**	**0.98**	**0.54**
Joseph	0.00	0.00	0.00
Lower Grande Ronde	0.00	0.00	0.00
Upper Grande Ronde	0.00	0.00	0.00
Imnaha	0.00	0.00	0.00

First, it was assumed the survival pattern in future years would be cyclic and be no less than 30% of the values observed for individual populations from 1973 to 1995, the baseline period.

Secondly, it was assumed changes in the proportion of hatchery fish in the naturally spawning population would have an effect on the future productivity of the population. This component was included in the model runs because the supposed relationship between the proportion of naturally spawning hatchery fish and overall population productivity was confirmed by the data (see Hatchery Impacts section). However, as described in this later section, the direct or indirect impact of hatchery fish on natural production was found to be much greater than expected. How this difference was added to the model runs was critical to outcomes for populations that involved hatchery fish. In particular, model runs for the Deschutes and Umatilla populations were extremely sensitive to how much reproductive discounting was applied to naturally spawning hatchery fish. Regardless, using the standard discounting approach described in the methods section, the results of supplemental PVA model runs suggested that if the future proportion of naturally spawning fish in the Deschutes and Umatilla populations was reduced by approximately 1/3, the probability of extinction would decrease to less than 0.05.

Assessment Synthesis

None of the populations examined meet the numerical abundance thresholds for threatened or endangered. In addition, the PVA model results suggest that only four of these populations are at significant conservation risk, populations in the middle Rogue, North Santiam, Deschutes, and Umatilla.

In the early 1990s, most populations entered a period of decline. For populations in the lower Columbia and upper Willamette ESUs, this decline appears to have been a feature that started prior to 1990. However, the record for the majority of other populations in Oregon, provides evidence that this decline may be part of a normal cyclic pattern. Rather than a chronic, long-term decline, as appears the case for the Willamette and lower Columbia populations, the pattern observed for most other populations suggests a long-term cyclic phenomena. Indeed, in the last 5 years several populations appear to be entering the ascending portion of this cycle.

The greatest concentration of vulnerable populations appeared to be those that belonged to the mid-Columbia ESU. Two populations, the

Deschutes and Umatilla, met the criteria for an endangered classification. A majority of the populations in this ESU are at abundance levels that are less than 50% of maximum seeding. Nearly equal, in terms of vulnerability, were the Upper Willamette populations. Only did 2 out 5 of these populations were at levels of escapement greater than necessary for 50% of maximum seeding. In addition, one population, the North Santiam, met the criteria for a threatened classification. Although, the PVA analysis did not suggest that the two populations representing the lower Columbia ESU, the Sandy and Clackamas, were at risk of extinction, these populations show other troubling signs. Both exhibit a chronic downward trend in abundance with little indication an underlying cyclic pattern exists that might reverse this trend. In addition, within the last 6 years, both populations have experienced at least one escapement of wild fish that was less than the viable threshold. Therefore, these populations may be more vulnerable than the PVA analysis seems to suggest.

In a less vulnerable category than the populations discussed in the previous paragraph, are those belonging to the KMP, the Oregon Coast and the Snake ESUs. The KMP is represented by 4 populations within the Rogue basin. Two of the populations, both winter-runs, appear quite healthy and are currently at levels greater than maximum seeding. The summer steelhead population upstream of Gold Ray Dam, while in considerably greater abundance than the level necessary for 50% of maximum seeding, has experienced a drop in numbers and now appear to be stabilizing at a new, lower level. The density of summer steelhead downstream of Gold Ray Dam is much lower than historical levels. They met the criteria for threatened classification. However, in recent years, particularly 2000, there has been a substantial increase over the extremely low spawner densities observed in the early 1990s.

This primary problem for the Oregon Coast ESU is that long-term data sets exist for only 3 populations, and 2 of these are found in the same basin, the Umpqua. Regardless, the winter and summer steelhead populations in the North Umpqua appear healthy. For both populations, the current number of wild fish exceeds the level necessary for maximum production. However, the only population north of the Umpqua for which there is adequate data, is the Salmonberry. Although, this population has a 6-year abundance average that is more the level necessary for 50% of maximum seeding, record low spawner densities have been experienced the last 3 years of this time series. While several ODFW biologists have expressed concern that these low values may be an artifact of modified stream survey methodologies, a means for accommodating these changes has not yet been devised.

All of the populations examined within the Snake ESU appear to be at abundance levels that are greater than 50% of maximum seeding. Both the Joseph and Imnaha populations have survived a period of extremely low spawner densities in the late 1970s. They are now substantially above these levels and seem to be in the beginning stages of an upward trend. The pattern for the other 2 Grande Ronde populations is more erratic. The upper Grande Ronde spawner density in the last 2 years has been very low. However, the productivity for these populations has remained greater than for many other populations during the recent low portion of the presumed survival cycle (Figures 1 through 5).

In terms of their conservation status, steelhead populations appear to fall into one of two groups. The healthier of the two groups contains steelhead populations belonging to the Snake, Oregon Coast, and KMP ESUs. Although not without problems and areas of concern, they are not at risk of extinction. Less healthy, is the group that contains populations belonging to the Middle Columbia, Lower Columbia, and Upper Willamette ESUs. Several of these populations are at substantial risk of extinction.

Mortality Rate Assessment

To assess the impact of human-caused fish mortality (e.g., fisheries) on the status and recovery of steelhead within the Columbia basin, a series of PVA model runs were performed for a range of different assumed adult mortality rates. For each population the probability of extinction over a 50-year time period was estimated for 16 mortality rates between 0% and 75%. In performing these model runs it should be clarified that the human mortality being discussed is primarily related to fisheries. Since this evaluation is based upon spawner-recruit relationships of the last 20 years, it incorporates a certain degree of background mortality associated with human activities such as the operation of dams and other adverse land uses. However, the mortality from these other activities is not directly accounted in this modeling exercise. Such accounting would be possible if reliable estimates for past and future levels of these additional human-caused mortalities were available. However, in this analysis, the future magnitude of these other sources of mortality was assumed to be the same as what they had been in the past.

For mortality rates between 0% and 20%, the probability of extinction remained at 0.00 for nearly all populations except the Middle Rogue, N. Santiam, Deschutes, and Umatilla populations (Table 3). The of the four exceptions, the Deschutes population appeared most vulnerable to mortalities imposed by fisheries. However, the actual vulnerability is probably less than these results suggest; particularly if this reduction in mortality rate was made by closing all steelhead fishing in the Deschutes basin. Such a closure would have its largest impact on the number of hatchery spawners in the basin. Under current regulations, hatchery steelhead may be caught and kept. However, all wild steelhead caught must be released. A consequence of closing this fishery would be to increase the proportion of naturally spawning hatchery fish in the basin, which would further reduce the population's productivity. Therefore, it is possible that the small gain in reduced survival could be cancelled by a substantial decrease in population productivity.

Table 3. PVA simulations of estimated probability of extinction in 50 years for 27 populations of Oregon steelhead under 16 different hypothetical adult mortality rates.

Population	**Percent Adult Mortality Rate**															
	0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**
Rogue SR												.00	.02	.90	1.0	1.0
MidRogueSR	.00	.01	.11	.41	.88	.99	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rogue WR														.00	.84	1.0
Applegate									.00	.46	1.0	1.0	1.0	1.0	1.0	1.0
NUmp SR												.00	.43	1.0	1.0	1.0
Nump WR													.00	.04	.99	1.0
Salmonberry								.00	.04	.25	.73	1.0	1.0	1.0	1.0	1.0
Calapooia				.00	.01	.08	.12	.30	.59	.88	.98	1.0	1.0	1.0	1.0	1.0
LoS.Santiam									.00	.02	.03	.05	.29	.51	.75	.92
UpS.Santiam										.00	.05	.51	.95	1.0	1.0	1.0
N. Santiam	.03	.11	.31	.63	.88	.99	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Molalla												.00	.01	.20	.68	.88
Clackamas														.00	.10	.91
Sandy												.00	.01	.20	.72	1.0
WarmSprings					.00	.01	.09	.28	.77	.99	1.0	1.0	1.0	1.0	1.0	1.0
Deschutes	.36	.53	.69	.85	.91	.98	.99	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
LowerNF JohnDay										.00	.01	.34	.84	1.0	1.0	1.0
Upper NF John Day																.00
M.Fork John Day						.00	.02	.14	.38	.77	.99	1.0	1.0	1.0	1.0	1.0
S.Fork John Day							.00	.05	.17	.53	.92	1.0	1.0	1.0	1.0	1.0
LowerMainsJohnDay							.00	.01	.04	.10	.13	.27	.47	.69	.94	1.0
UprMainsJohn Day					.00	.01	.04	.18	.41	.62	.90	.99	1.0	1.0	1.0	1.0
Umatilla	.01	.08	.21	.57	.85	.98	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
UprGrRond												.00	.03	.27	.78	.99
MidGrRond							.00	.01	.13	.77	1.0	1.0	1.0	1.0	1.0	1.0
Joseph															.00	.29
Imnaha										.00	.01	.09	.74	1.0	1.0	1.0

Therefore, closing a sport fishery in order to gain, in most cases, no more than a 5% reduction in wild fish mortality, would be counter productive in basins where hatchery fish are commonly caught and removed from the population. In such basins, such a strategy would likely make the status of the wild population worse instead of better. The interpretation of the results presented in Table 3 should keep this practical management consideration in mind.

For most populations, the model predicted the risk of extinction was very low until the mortality rates reached 30%. However, once the mortality rate became greater than 40%, the probability of extinction among the remaining populations began to increase. There was considerable difference among populations at what mortality rate the probability of extinction started to increase.

There also appeared to be a threshold mortality rate at which the transition to a 100% probability of extinction was rapid. For most populations, once a mortality rate was found that increased the probability of extinction above 0.00, an increment of an additional 15% to 25% in mortality rate was usually sufficient to result in a probability of extinction of 1.00. For example, the probability of extinction for the Warm Springs population under a 25% mortality rate was 0.01. However, the probability of extinction increased to 0.99 when the model was run using a 45% mortality rate. Therefore, it appears that while most of these populations can withstand moderate levels of adult mortality with no significant impact on their likelihood of persistence, once the mortality level goes past the trigger point, the probability of extinction increases suddenly.

Since the transition from low risk to high risk happens so rapidly once the critical mortality rate is exceeded, management strategies should set a limit on maximum mortality rates at some level considerable less than this trigger point. To do otherwise leaves no room for logic errors in the model used to forecast these impacts, nor does it allow for any error in the actual measurement of mortality rates.

For most populations the trigger point is a mortality rate of 30% or higher. Taking a conservative approach, it seems that a mortality rate limit of 20% is a reasonable conservation standard for most steelhead populations in Oregon.

The mortality rate assessment described here was based upon adult mortalities. Therefore, it would seem best suited for evaluating the impact of various fishery management strategies. However, various sampling, monitoring, and collection activities will also impact steelhead at the juvenile life history stage. One way to account for the impact of mortality on juvenile steelhead would be to convert each life history stage (i.e., eggs, fry, parr, and smolts) into adult equivalents. Once stated in terms of adult equivalents they could be converted into a cumulative mortality rate and a determination made if the population was under the critical management level (e.g., 20%).

However, there are some serious flaws with this approach. First, for the majority of populations in the Columbia basin the method of population assessment is redd surveys. For a variety of technical reasons, converting these redd per stream mile index counts into a spawner estimate for an entire population with any reliability is very difficult, at least with the current state of the knowledge about this species and the habitat characteristics of each basin. Second, without a reliable total run-size or spawner estimate, juvenile mortalities converted into adult equivalents have limited value because it would not be possible to estimate the proportion they represent of the total population. Third, converting to adult equivalents means assigning an expected survival rate for each juvenile life history stage to adulthood. Although such survival rates have been estimated, they are highly variable for many reasons including: spawner densities, habitat quality, climatic variations, inter and intra-specific competition, predation, and disease.

A more viable approach for assessing the impact of activities that cause juvenile mortality is to base them on a direct estimate of the mortality rate**,** rather than numbers in adult equivalents. For example, the number of smolts killed in the course of operating a smolt trap can be expressed as a mortality rate. Or if 1 out of every 50 fry encountered during electroshocking surveys are killed then this can be converted to a mortality rate. In the latter example, this mortality rate would be weighed in proportion to the amount of steelhead habitat for the entire population. However, even if this was not possible, localized estimates could be used as the maximum likely mortality rate for the entire population, a very conservative, yet feasible approach.

Although, the survival rates of fry and parr to the smolt stage are higher when the spawner seeding level is lower (density dependent survival), one could make the conservative assumption that this survival is density independent at all life history stages. Essentially, this is the assumption that the habitat is extremely underseeded and there is no competition for space and food among juvenile steelhead. With this assumption, the life history stage at which mortality occurs is not a complication as long as it is expressed in terms of a mortality rate for the entire population. Under this assumption of density independent survival, if 10% of the members of a population are killed because of some management action, the impact is the same, regardless if it happens at the fry, smolt, or adult stages.

With this operating assumption, the mortality across all life history stages could be combined into one cumulative mortality rate using a simple equation such as:

Cumulative mortality rate = $1-[(1-M_f)*(1-M_p)*(1-M_s)*(1-M_a)]$

Where M_f, M_p, M_s, and M_a equal the estimated mortality rate at the life history stage of fry, parr, smolt, and adult, respectively. Using this approach, once the cumulative, life history mortality rate was calculated for a population, the resulting probability of high risk could be estimated directly from population specific PVA modeling results such as those shown in Table 3. For example, a cumulative mortality rate of 30% for the North Santiam population corresponds with an extinction probability of 0.25, exceeding the criteria for an endangered classification (i.e., a 0.20 probability of extinction. Therefore, if a cumulative mortality rate of 30% occurred for the North Santiam population, its conservation status could be expected to change from sensitive to endangered.

Hatchery Impacts

For many of the populations assessed, hatchery fish are present in the production areas used by wild fish and spawn naturally. In comparing such mixed populations, it appears that the higher the proportion of hatchery fish, the poorer the subsequent recruitment of naturally produced offspring (Chilcote, 1998). However, from 1998 to present several major changes in hatchery programs were made to reduce the number of naturally spawning hatchery fish. Some of these changes are expected to eliminate naturally spawning hatchery fish altogether, especially for populations in the Lower Columbia and Upper Willamette. Therefore, to model the future status of such populations with the PVA methodology, it was necessary to make a positive adjustment in their reproductive potential to account for the removal of the hatchery fish. The procedure for accomplishing this has been previously described in the Analytical Concepts and Methods section of this report. The discussion that follows here describes some of the key findings that were a byproduct of developing this adjustment procedure for the PVA modeling.

The relationship between the proportion of hatchery fish in 15 natural populations and their respective productivity was evaluated for 12 different time intervals (Table 4). This comparison was based on 15 populations, 12 of which had hatchery fish present on the spawning grounds at some point during the last 25 years. In addition, data had been collected on each of these 12 populations to measure proportion of hatchery fish. The remaining 3 populations were comprised only of wild fish. They were selected to provide some reference points for the "no hatchery fish" condition.

In all 12 cases, a negative relationship was found; the higher the proportion of hatchery fish in the spawning population, the more population productivity declined, as measured by the value for the ***a*** parameter in the Ricker recruitment function (Figures 7 through 9). Nine of the 12 regressions were statistically significant (Table 5). Of the 3 that were not significant, the common problem was an anomalous data point for the Sandy population (Figures 7 and 8). For the 3 time intervals in question, it was decided that the regressions without the Sandy data would be used. The rationale for this decision was based upon a closer examination of the data points from which the ***a*** parameters were estimated for the Sandy population between the brood years 1982 and 1990. This period was characterized by a rapid transition to very low productivity and rather large escapements. This combination, by chance, yielded a very steep regression line which intersected the y axis (the y-intercept is the estimate for ***a***) at an unlikely high value. When the Sandy data point was removed from these 3 regressions, they all became statistically significant.

It should also be noted that not all regressions were based upon the data from 15 populations. For the earlier time periods, this was because the data set for the Molalla and the N. Santiam did not start until the 1980 and 1983 brood years, respectively (Table 4). For the later time periods, fewer populations were represented because for some populations with an older age structure, the total number of recruits for the 1994 and 1995 brood years can not be estimated until that adult returns for 2001 or 2002 have been counted (Table 4).

The results presented here lead to the conclusion that overall population productivity can be adversely effected by naturally spawning hatchery fish. Further that this effect is not minor. For nearly all of the time intervals evaluated, it appears that when the proportion of hatchery fish exceeds 60%, the population can no longer replace its self, even at very low densities where the recruitment function would predict that survival would be at its greatest.

It is unclear whether the mechanism for this relationship is genetic or environmental. However, if it is genetic, the use of wild fish from local populations for hatchery broodstock does not appear to be a corrective solution. The evidence for this statement is in the distribution of data points around the regression lines describing the negative relationship between productivity and hatchery fish proportion for each of the 12 time intervals evaluated (Figures 7 through 9). Some of these data points represent populations with hatchery fish that were derived from local, wild fish. In contrast, other data points are from populations where the hatchery fish are of non-local origin and may be partially domesticated.

Table 4. Steelhead populations used in comparing productivity and proportion of hatchery fish over 12 time intervals, "x" denotes inclusion of population in regression analysis.

	Time Interval for Regressions											
Population	78 to 84	79 to 85	80 to 86	81 to 87	82 to 88	83 to 89	84 to 90	85 to 91	86 to 92	87 to 93	88 to 94	89 to 95
Joseph	x	x	x	x	x	x	x	x	x	x		
Imnaha	x	x	x	x	x	x	x	x	x	x	x	
Upr Grande Ronde	x	x	x	x	x	x	x	x	x	x		
Lwr NFk. John Day	x	x	x	x	x	x	x	x	x	x	x	
Umatilla	x	x	x	x	x	x	x	x	x	x	x	
Deschutes	x	x	x	x	x	x	x	x	x	x		
Sandy	x	x	x	x	x	x	x	x	x	x	x	x
Clackamas	x	x	x	x	x	x	x	x	x	x	x	x
Molalla			x	x	x	x	x	x	x	x	x	x
North Santiam						x	x	x	x	x	x	x
Upr S. Santiam	x	x	x	x	x	x	x	x	x	x	x	x
N.Umpqua SR	x	x	x	x	x	x	x	x	x	x	x	x
N.Umpqua WR	x	x	x	x	x	x	x	x	x	x	x	
Rogue SR	x	x	x	x	x	x	x	x	x	x	x	x
Rogue WR	x	x	x	x	x	x	x	x	x	x	x	x

Table 5. Statistics for linear regressions of population productivity and proportion of naturally spawning hatchery fish based upon 15 Oregon steelhead populations over 12 time intervals.

Time Interval	**n**	**R^2**	**p**	**Intercept**	**Slope**
1978 – 84	13	0.39	0.022	2.130	-3.700
1979 – 85	13	0.74	0.000	2.180	-4.270
1980 – 86	14	0.76	0.000	2.040	-3.270
1981 – 87	14	0.72	0.000	2.080	-3.060
1982 – 88 w/ Sandy	**14**	**0.15**	**0.175**	**1.8681**	**-1.377**
1982 – 88 w/o Sandy	13	0.70	0.000	1.920	-2.870
1983 – 89 w/ Sandy	**15**	**0.16**	**0.127**	**1.4901**	**-2.283**
1983 – 89 w/o Sandy	14	0.56	0.002	1.620	-4.440
1984 – 90 w/ Sandy	**15**	**0.19**	**0.096**	**1.2412**	**-2.8329**
1984 – 90 w/o Sandy	14	0.62	0.001	1.420	-5.270
1985 – 91	15	0.47	0.005	0.770	-3.420
1986 – 92	15	0.55	0.002	1.010	-4.480
1987 – 93	15	0.66	0.001	1.050	-3.320
1988 – 94	11	0.70	0.000	1.192	-3.898
1989 - 95	8	0.93	0.000	1.705	-4.106

If the use of wild fish for hatchery broodstock is a strategy that improves the genetic adaptation and reproductive success of naturally spawning hatchery fish, then the data points from these types of programs should consistently appear above the regression line (more productive than the average). The corollary would be that the data points from populations that contain hatchery fish from non-local, domesticated sources, should consistently fall below the regression line (less productive than the average).

However, this is not the pattern that was observed. In the regression analyses performed, the populations with hatchery fish that have been predominately non-local origin are the upper Grand Ronde, Deschutes, Sandy, Clackamas, and Molalla. Those populations with local, "wild-type" hatchery fish are the Imnaha, Umatilla, N. Santiam, S. Santiam, Umpqua summer-run, Rogue summer-run and Rogue winter-run. If the data points from all 12 regressions (time intervals) are combined, 39 points can be assigned to populations with non-local hatchery fish and 63 to populations with "wild-type" hatchery stocks. When these points were further classified as to whether they fall above or below the regression line, the two types of populations did not differ. For populations with "wild-type" hatchery fish, 60% of the data points were above the regression line. For populations with non-local, domesticated hatchery fish, 62% of the data points were above the regression line.

These results lead to one of two conclusions. Either that the use of wild fish in hatchery programs does solve the genetic problem that makes hatchery fish genetically maladapted for natural survival. A conclusion that implies rapid and significant genetic change occurs when fish are brought into the hatchery environment.

Alternatively, that the use of wild fish for hatchery broodstock greatly reduces the genetic difference between hatchery and wild fish, but this really doesn't matter because the mechanism causing the reduced productivity for naturally spawning hatchery is not genetic. The problem is caused by some unknown environmental impact of the hatchery rearing environment that results in hatchery fish being less able to produce viable offspring under natural conditions.

Regardless of the mechanism, when hatchery fish mix with wild fish in natural production areas, the overall productivity of the population declines. In effect the freshwater habitat becomes less efficient in producing steelhead. Not only does this mean that natural production goals are compromised, it means that the population's vulnerability to extinction is increased.

Zones of Inference

It was not possible to perform an assessment on every steelhead population in Oregon. This was either due to lack of representative data or data sets that did cover enough years for the analytical approach used here. In particular, specific coverage was not possible for much of the Oregon coast as well as portions of the Grande Ronde and Imnaha basins.

However, in examining the results for populations for which there were data, there was not a great deal of variation with respect their status within each ESU. With certain exceptions, such as the Deschutes, the consistency of the assessment results suggests that the zone of inference concerning the biological health for these populations is probably at the ESU level. Therefore, where specific information on a specific population or sub-population does not exist, it is reasonable to infer that its status is probably similar to that of other populations within the same ESU for which an assessment exists.

In addition, the sensitivity of steelhead populations to mortality (fishery or other sources) appears relatively consistent, again with a few exceptions. Therefore, in terms of mortality impact, the zone of inference is sufficiently broad to conclude that as long as the mortality rate does not exceed 20%, the probability of extinction is very low (the model results suggest zero).

Finally, with respect to hatchery programs, the impact of naturally spawning hatchery fish on the capacity of a population to produce recruits appears universally adverse. Therefore, the zone of inference concerning the impact of naturally spawning hatchery on wild populations is statewide. Without specific data to the contrary, it is a reasonable inference that wild steelhead populations are better off when returning hatchery fish are prevented from escaping into natural spawning areas.

References

Allendorf, F.W., D.Bayles, D.L.Bottom, K.P. Currens, C.A. Frissel, D.Hankin, J.A. Lichatowich, W. Nehlsen, P.C. Trotter, and T.H. Williams. 1997. Prioritizing Pacific Salmon Stocks for Conservation. Conservation Biology 11:140-152.

Burgman, M.A., S. Ferson, H.R Akcakaya. 1993. Risk assessment in conservation biology, 314p. Chapman and Hall, London.

Chilcote, M.W., S.A. Leider, J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115:726-735

Chilcote, M. W. 1998. Conservation Status of Steelhead in Oregon. Information Report 98-3. Oregon Department of Fish and Wildlife, Portland, 108p.

Glipin, M.E. and M.E. Soule. 1986. Minimum viable populations: process of species extinction, in *Conservation Biology: the Science of Scarcity and Diversity* (ed M. E. Soule), Sinauer, Sunderland, Massachusetts, pp 19-24.

Kostow, K.(editor). 1995. Biennial report of the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland, Oregon, 247p.

Leider, S.A., P.L. Hulett, J. J. Loch, and M.W. Chilcote. 1990. Electropohoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88:239-252.

Mace, G. M. and Lande, R. 1991. Assessing extinction threats: towards a reevaluation of IUCN threatened species categories. Conservation Biology, 5:148-157.

McElhaney, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

NMFS (National Marine Fisheries Service). 2000. Template for developing a fisheries management and evaluation plan (FMEP) under “4(d) rules”. Unpublished information document, U.S. Dept. Commer., NMFS, Portland, Oregon, 17p. Unpublished information document.

Nickelson, T. E., M.F. Solazzi, and S.L. Johnson. 1986. Use of hatchery coho salmon (*Oncorhynchus kisutch*) presmolts to rebuild wild populations in Oregon coast streams. Can. J. Fish. Aquat. Sci. 43:2443-2449.

Reisenbichler, R.R. and S.P. Rubin. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ECES Journal of Marine Science, 56:459-466.

Reisenbichler, R.R. and J.D. McIntyre. 1977 Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*. Journal of Fisheries Research Board of Canada, 34:123-128.

Sharp, C., P. Hulet, and C. Wagemann. 2000. Studies of hatchery and wild steelhead in the lower Columbia region, Progress report of fiscal year 1998. Washington Department of Fish and Wildlife, Olympia, Wa 36p.

Smith, B.D. 2000. Trends in wild steelhead (Oncorhynchus mykiss) abundance for snowmelt-driven watersheds of British Columbia in relation to freshwater discharge. Can. J. Fish. Aquat. Sci. 57:285-297.

Smith, B.D. and B.R. Ward. 2000. Trends in wild adult steelhead (Oncorhynchus mykiss) abundance for coastal regions of British Columbia support the variable marine survival hypothesis. Can. J. Fish. Aquat. Sci. 57:274-284.

Thompson, G.G. 1991. Determining minimum viable populations under the Endangered Species Act. NOAA technical memorandum NMFS F/NWC-198. National Marine Fisheries Service, Seattle.

Welch, D.W., B.R. Ward, B.D. Smith, and J.P. Eveson. 2000. Temporal and spatial responses of British Columbia steelhead (*Oncorhynchus mykiss*) populations to ocean climate shifts. Fish. Oceanogr. 9: 17-32.

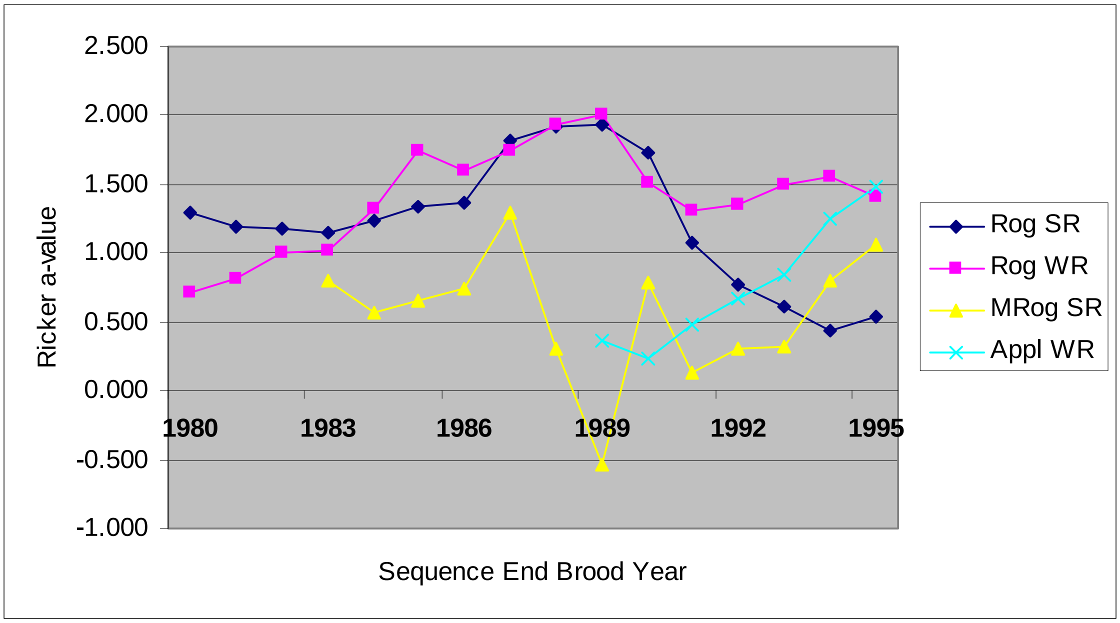


Figure 1. Temporal distribution of Ricker ***a***-values estimated from 7-brood year sequences of spawner recruit data from 1980 to 96 for 4 populations of Rogue River steelhead.

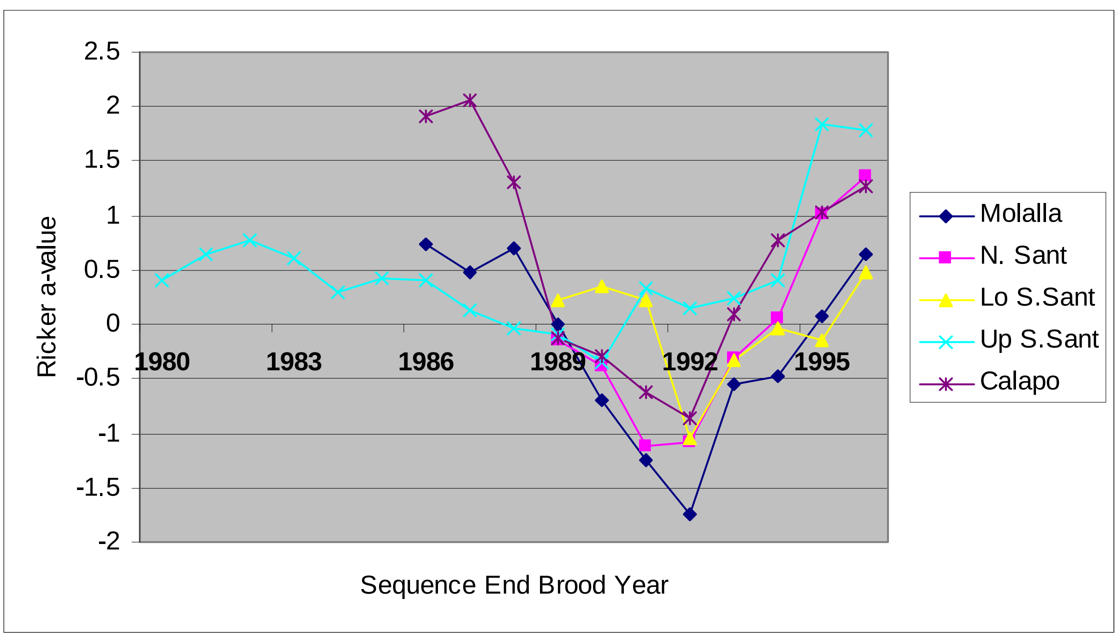


Figure 2. Temporal distribution of Ricker ***a***-values estimated from 7-brood year sequences of spawner recruit data from 1980 to 96 for 5 populations of Willamette River steelhead.

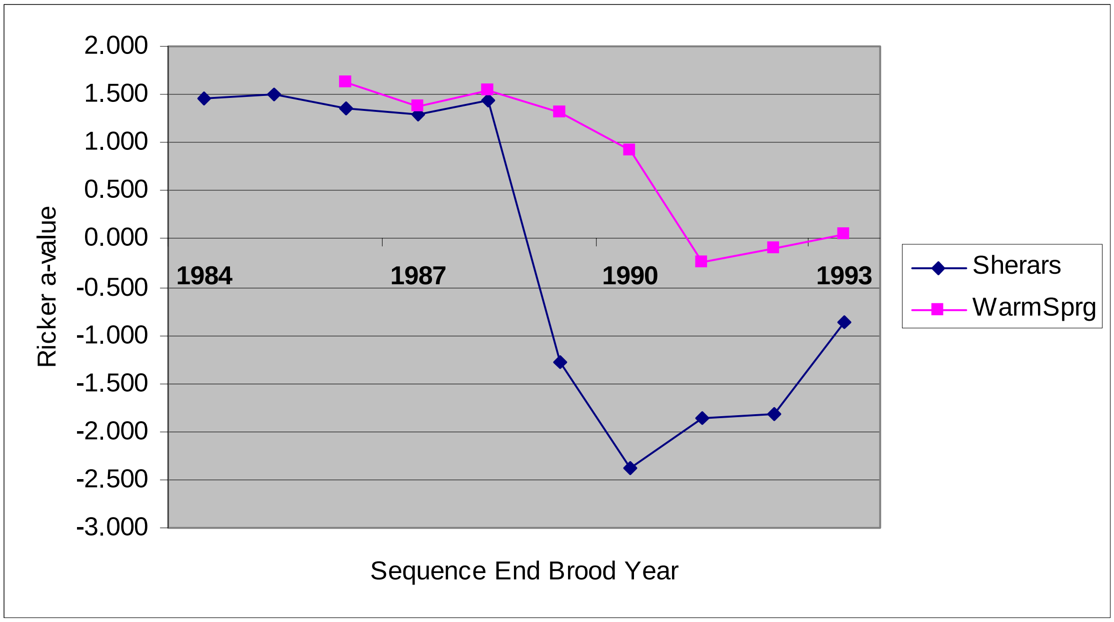


Figure 3. Temporal distribution of Ricker a-values estimated from 7-brood year sequences of spawner recruit data from 1980 to 96 for 5 populations of Deschutes River steelhead.

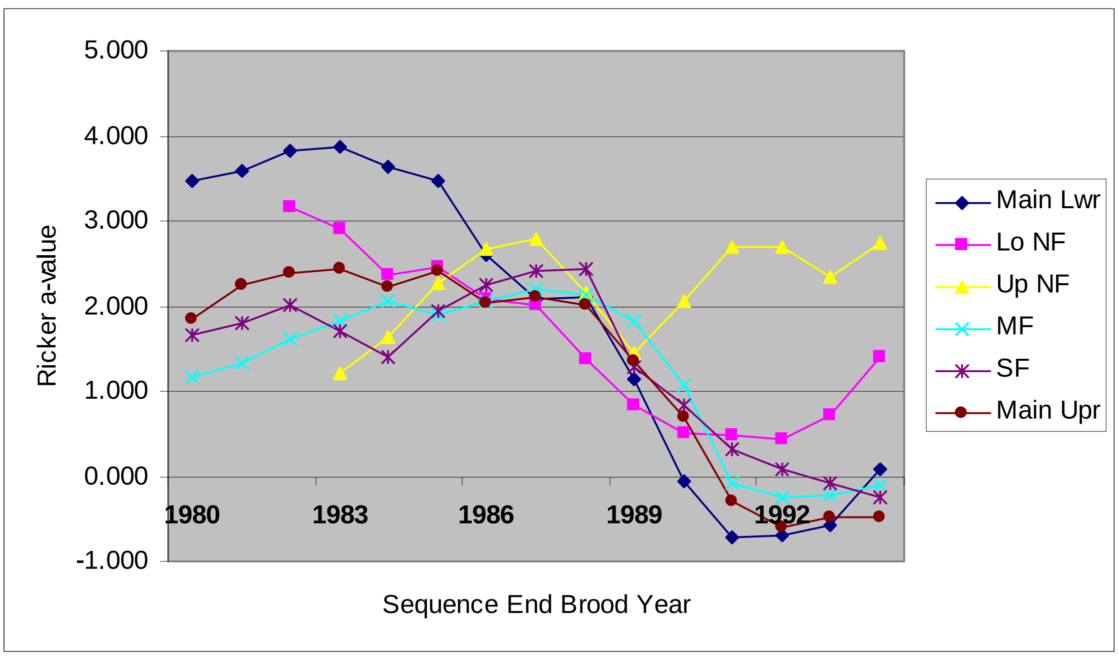


Figure 4. Temporal distribution of Ricker a-values estimated from 7-brood year sequences of spawner recruit data from 1980 to 96 for 6 populations of John Day River steelhead.

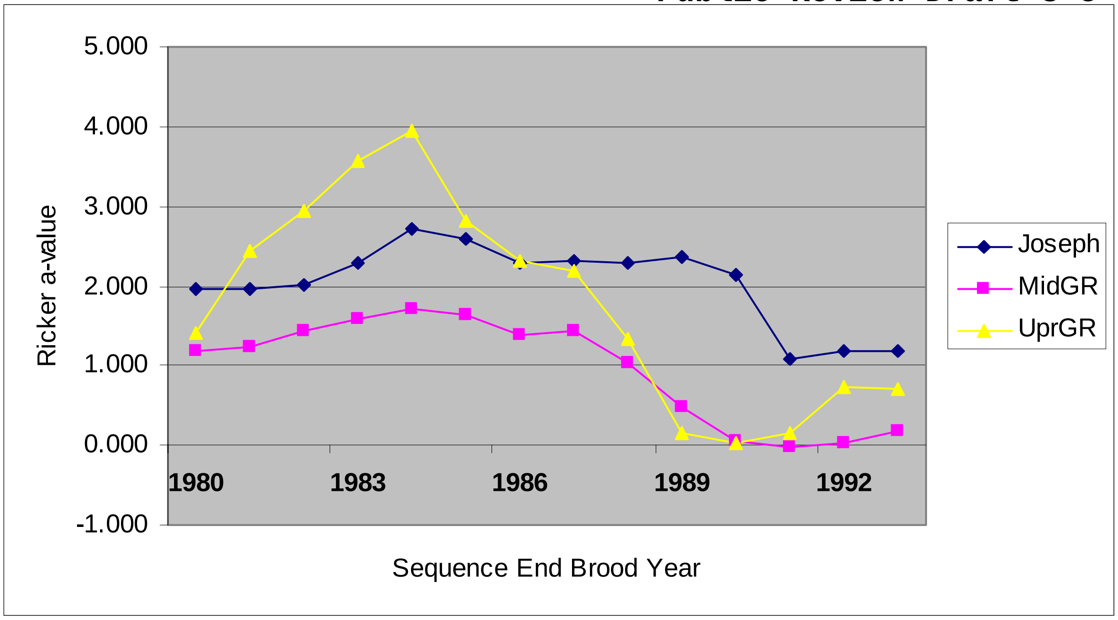


Figure 5. Temporal distribution of Ricker ***a***-values estimated from 7-brood year sequences of spawner recruit data from 1980 to 96 for 3 populations of Grande Ronde River steelhead.

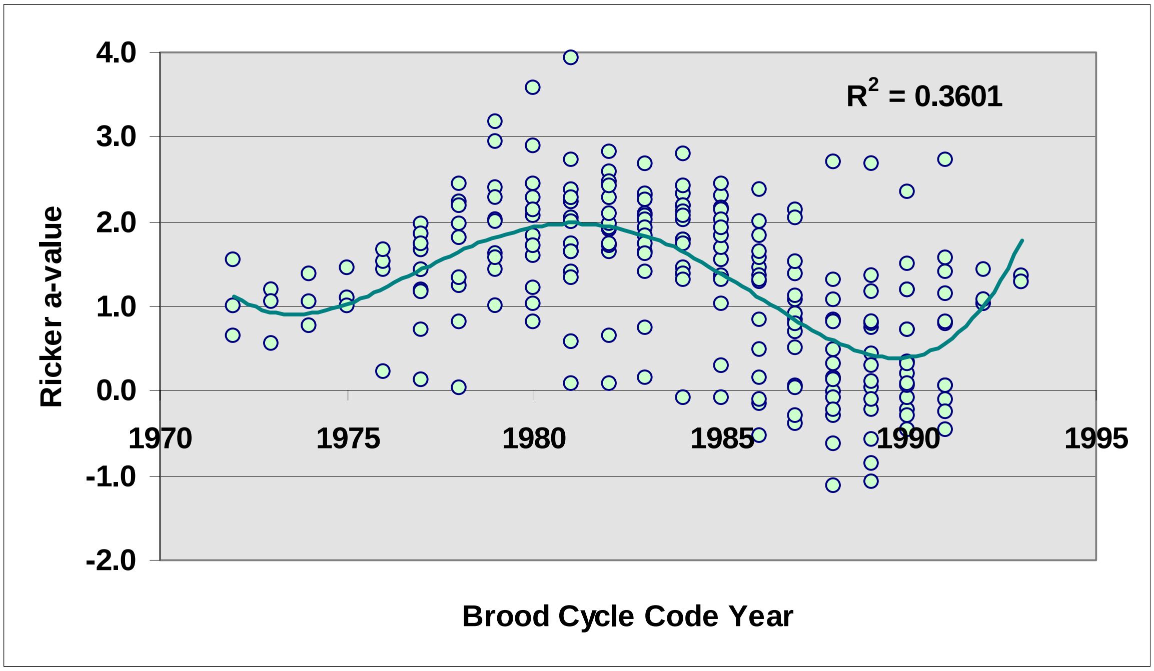


Figure 6. Temporal distribution of Ricker ***a***-values estimated from 7-brood year sequences of spawner-recruit data from 1972 to 1993 brood cycle code years for 15 populations of Oregon steelhead comprised of less than 15% hatchery fish.

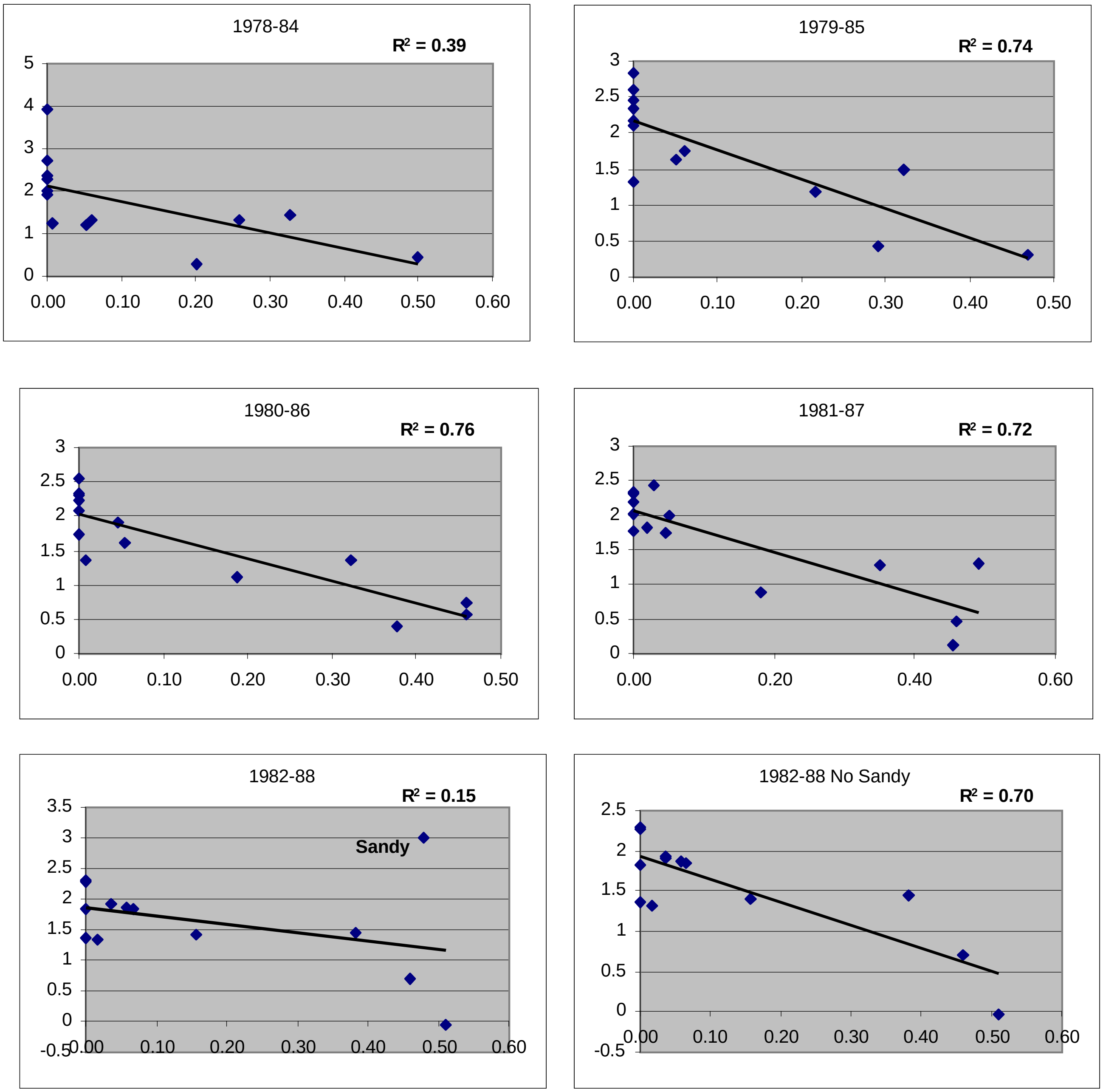


Figure 7. Relationship between productivity (vertical axis) and proportion of hatchery fish in spawning population (horizontal axis) for 15 steelhead populations for 5 time intervals. Last two panels of graph from 1982-88 time interval, with and without data point for Sandy population.

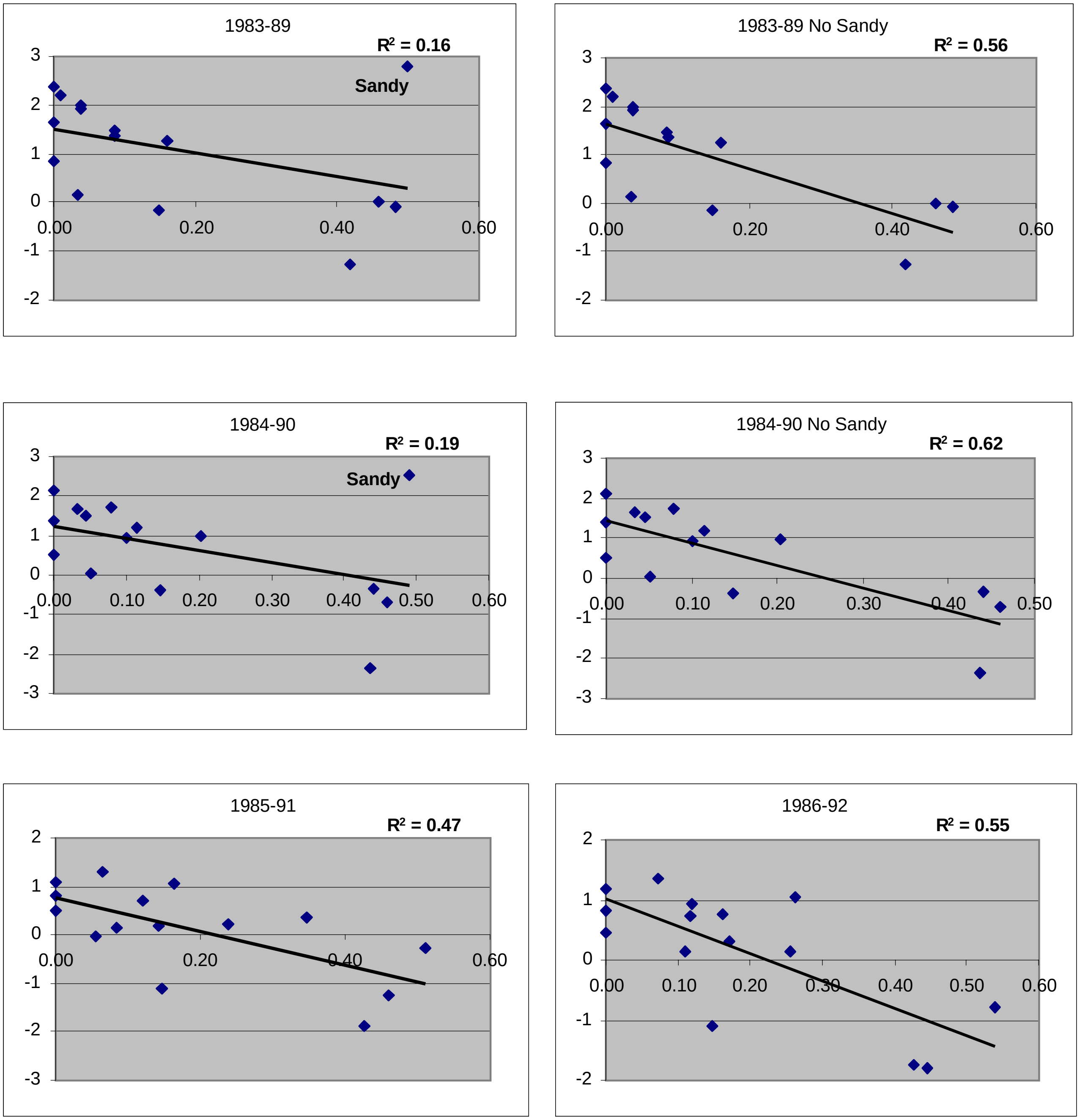


Figure 8. Relationship between productivity (vertical axis) and proportion of hatchery fish in spawning population (horizontal axis) for 15 steelhead populations for 5 time intervals. First 4 panels of graph represent data with and without Sandy population for the 1982-88 and 1983-89 time intervals.

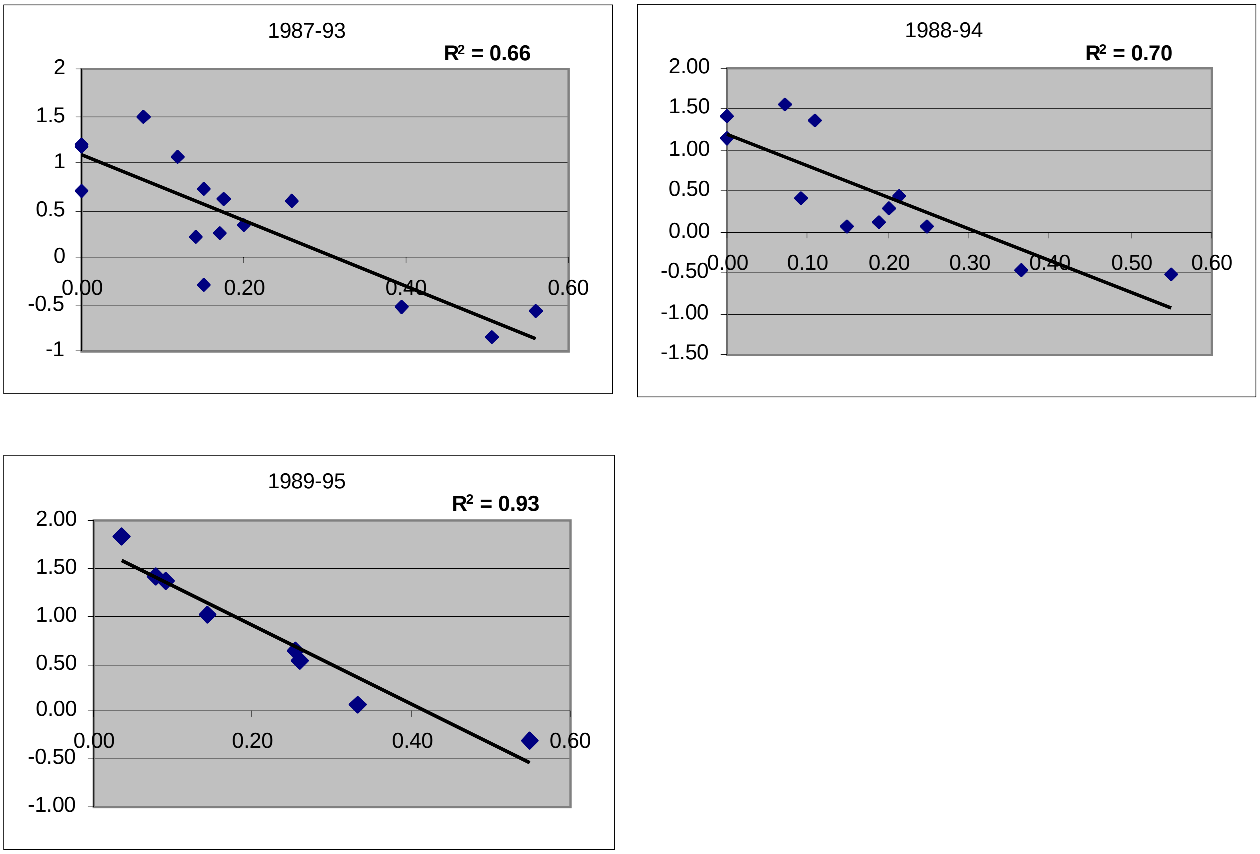


Figure 9. Relationship between productivity (vertical axis) and proportion of hatchery fish in spawning population (horizontal axis) for 15 steelhead populations for 5 time intervals. First 4 panels of graph represent data with and without Sandy population for the 1982-88 and 1983-89 time intervals.

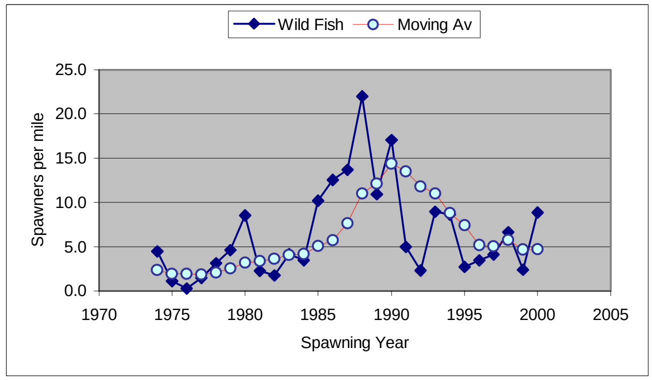
Appendix 1. Presumed steelhead populations and sub-populations in Oregon's portion of the Columbia River basin.

ESU	Population	Sub-population	Description
Upper Willamette	Calapooia		
	Lower S. Santiam		Basin from N. Santiam to Wiley Creek (downstream from Foster Dam)
	Upper S.Santiam		Basin from Foster Dam upstream
	North Santiam		
	West Valley	Luckiamute	
		Rickreall	
		Yamhill	
		Tualatin	
	Molalla		
Lower Columbia	Scappose		
	Clackamas	Abernathy	
		Clackamas	
	Sandy	Sandy	
	Columbia Gorge	Tanner	
		Eagle	
		Herman	
		Lindsey	
	Hood WR		Winter Steelhead
	Hood SR		Summer Steelhead
Middle Columbia	Fifteenmile	Chenowith	Winter Steelhead
		Fifteenmile	Winter Steelhead
	Deschutes		Basin except Warm Springs
	Warm Springs		
	Lower John Day		Basin from mouth to South Fork John Day, exclusive of North Fork John Day
	Lower North Fork John Day		North Fork Basin from Mainstem John Day to Middle Fork John Day
	Upper North Fork John Day		North Fork Basin from Middle Fork John Day upstream
	Middle Fork John Day		
	South Fork John Day		
	Upper John Day		John Day Basin upstream of South Fork John Day
	Umatilla	Lower Umatilla	Basin downstream McKay Creek
		Upper Umatilla	Basin upstream from McKay Creek except Meacham Creek drainage

		Meacham Creek	
	Walla Walla	Middle Walla Walla	Basin above Touchet R. up and including Cottonwood Creek
		Upper Walla Walla	Basin above Cottonwood Creek
Snake	Lower Grande Ronde	Wenaha	
		Lower Mainstem	Grande Ronde basin from state line to (and including) Phillips Crk, exclusive of Wenaha, Joseph Crk, and Lookingglass Crk
		Lookingglass	
	Joseph		
	Wallowa	North Wallowa	Wallowa tributaries on northern side of basin up to Prairie Creek
		South Wallowa	Wallowa tributaries on southern side of basin, exclusive of Minam
		Prairie	
		Minam	
	Upper Grande Ronde	Middle Mainstem	Grande Ronde basin tributaries from Phillips Creek to upper end of Grande Ronde valley (near the city of La Grande) exclusive of Catherine and Willow Creeks
		Willow	
		Catherine	
		Upper Mainstem	Grande Ronde basin tributaries from upper end of Grande Ronde valley (near the city of La Grande) up to and including Meadow Creek.
		South Upper Mainstem	Grande Ronde basin upstream from Meadow Creek.
	Imnaha	Zumwalt	Camp Creek and tributaries on the west side of the basin from downstream from Big Sheep Creek.
		Lower Imnaha	Tributaries on the eastern portion of the basin downstream from Big Sheep Creek.
		Big Sheep	
		Upper Imnaha	Basin upstream of Big Sheep Creek
	Snake	Hell's Canyon	Oregon tributaries from state line to Hell's Canyon Dam.

Appendix 2. "Populations at a glance" information summaries for 27 populations of steelhead within Oregon.

Basin:	**Imnaha**
Population:	**Imnaha**
Sub-population:	Zumwalt
Monitoring sites:	**Camp Creek**
Method:	**Redd Surveys**



Critical Threshold	0.36
Viable Threshold	1.20
Last 6-yr Average	**4.70**

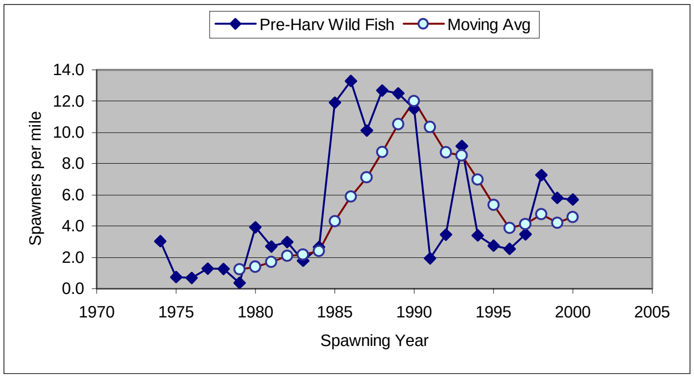
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.03	0.00	0.03	0.65	0.28	0.00

Spawning	Redds/Mile		Fish/Mile		Effective	Harvest Rates			Pre- Harv	6-yr.
Year	Wild Fish	Hatch Fish	Wild Spwnrs	Hatch Spnrs	Spawners	Columbia	In-basin	Combined	Wild Fish	Moving Av
1974	2.30	0.00	3.11	0.00	3.11	0.289	0.02	0.30	4.5	2.4
1975	0.70	0.00	0.95	0.00	0.95	0.128	0.02	0.15	1.1	1.9
1976	0.20	0.00	0.27	0.00	0.27	0.067	0.02	0.09	0.3	2.0
1977	1.00	0.00	1.35	0.00	1.35	0.078	0.02	0.10	1.5	1.8
1978	1.80	0.00	2.43	0.00	2.43	0.208	0.02	0.22	3.1	2.1
1979	2.70	0.00	3.65	0.00	3.65	0.196	0.02	0.21	4.6	2.5
1980	5.70	0.00	7.70	0.00	7.70	0.079	0.02	0.10	8.5	3.2
1981	1.50	0.00	2.03	0.00	2.03	0.087	0.02	0.11	2.3	3.4
1982	1.20	0.00	1.62	0.00	1.62	0.069	0.02	0.09	1.8	3.6
1983	2.80	0.00	3.78	0.00	3.78	0.069	0.02	0.09	4.1	4.1
1984	2.30	0.00	3.11	0.00	3.11	0.088	0.02	0.11	3.5	4.1
1985	6.50	0.00	8.78	0.00	8.78	0.121	0.02	0.14	10.2	5.1
1986	7.20	0.00	9.72	0.00	9.72	0.209	0.02	0.23	12.5	5.7
1987	8.56	2.14	11.56	2.89	14.45	0.139	0.02	0.16	13.7	7.6
1988	13.44	3.36	18.14	4.54	22.68	0.158	0.02	0.17	22.0	11.0
1989	6.56	1.64	8.86	2.21	11.07	0.172	0.02	0.19	10.9	12.1
1990	10.40	2.60	14.04	3.51	17.55	0.161	0.02	0.18	17.1	14.4
1991	3.04	0.76	4.10	1.03	5.13	0.160	0.02	0.18	5.0	13.5
1992	1.44	0.36	1.94	0.49	2.43	0.147	0.02	0.16	2.3	11.8
1993	5.44	1.36	7.34	1.84	9.18	0.164	0.02	0.18	9.0	11.0
1994	5.28	1.32	7.13	1.78	8.91	0.155	0.02	0.17	8.6	8.8
1995	1.76	0.44	2.38	0.59	2.97	0.105	0.02	0.12	2.7	7.4
1996	2.24	0.56	3.02	0.76	3.78	0.106	0.02	0.12	3.5	5.2
1997	2.72	0.68	3.67	0.92	4.59	0.090	0.02	0.11	4.1	5.0
1998	4.32	1.08	5.83	1.46	7.29	0.105	0.02	0.12	6.6	5.8
1999	1.60	0.40	2.16	0.54	2.70	0.090	0.02	0.11	2.4	4.7
2000	5.92	1.48	7.99	2.00	9.99	0.079	0.02	0.10	8.9	4.7

Basin:	**Grande Ronde**
Population:	**Joseph**
Sub-population:	
Monitoring sites:	**Butte Creek** **Crow Creek** **Elk Creek** **Peavine Creek** **Swamp Creek**
Method:	**Redd Surveys**



Critical Threshold	0.19
Viable Threshold	0.67
Last 6-yr Average	**4.59**

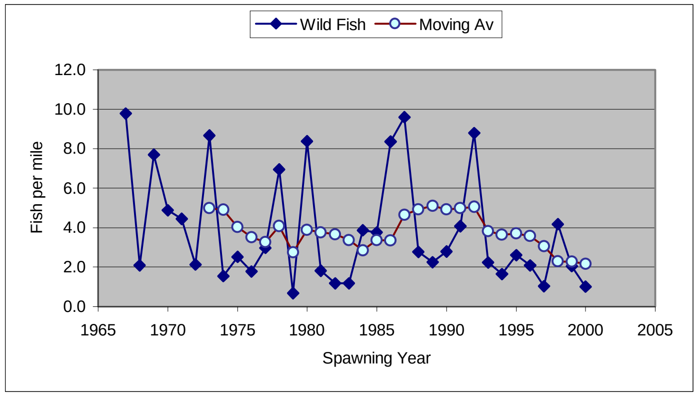
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.03	0.00	0.02	0.38	0.44	0.13

Spawning	Redds/Mile		Fish/Mile		Effective	Harvest Rates			Pre- Harv	6 year
Year	Wild Fish	Hatch Fish	Wild Spwnrs	Hatch Spnrs	Spawners	Columbia	In-basin	Combined	e-Harv Wild Fi	Moving Avg
1974	1.6	0.0	2.1	0.0	2.1	0.289	0.02	0.30	3.0	
1975	0.5	0.0	0.6	0.0	0.6	0.128	0.02	0.15	0.7	
1976	0.5	0.0	0.6	0.0	0.6	0.067	0.02	0.09	0.7	
1977	0.9	0.0	1.2	0.0	1.2	0.078	0.02	0.10	1.3	
1978	0.7	0.0	1.0	0.0	1.0	0.208	0.02	0.22	1.3	
1979	0.2	0.0	0.3	0.0	0.3	0.196	0.02	0.21	0.4	1.2
1980	2.6	0.0	3.6	0.0	3.6	0.079	0.02	0.10	3.9	1.4
1981	1.8	0.0	2.4	0.0	2.4	0.087	0.02	0.11	2.7	1.7
1982	2.0	0.0	2.7	0.0	2.7	0.069	0.02	0.09	3.0	2.1
1983	1.2	0.0	1.6	0.0	1.6	0.069	0.02	0.09	1.8	2.2
1984	1.8	0.0	2.4	0.0	2.4	0.088	0.02	0.11	2.7	2.4
1985	7.6	0.0	10.3	0.0	10.3	0.121	0.02	0.14	11.9	4.3
1986	7.6	0.0	10.3	0.0	10.3	0.209	0.02	0.23	13.3	5.9
1987	6.3	0.0	8.6	0.0	8.6	0.139	0.02	0.16	10.1	7.1
1988	7.8	0.0	10.5	0.0	10.5	0.158	0.02	0.17	12.7	8.7
1989	7.5	0.0	10.2	0.0	10.2	0.172	0.02	0.19	12.5	10.5
1990	7.0	0.0	9.5	0.0	9.5	0.161	0.02	0.18	11.5	12.0
1991	1.2	0.0	1.6	0.0	1.6	0.160	0.02	0.18	1.9	10.3
1992	2.1	0.0	2.9	0.0	2.9	0.147	0.02	0.16	3.4	8.7
1993	5.5	0.0	7.5	0.0	7.5	0.164	0.02	0.18	9.1	8.5
1994	2.1	0.0	2.8	0.0	2.8	0.155	0.02	0.17	3.4	7.0
1995	1.8	0.0	2.4	0.0	2.4	0.105	0.02	0.12	2.7	5.4
1996	1.6	0.0	2.2	0.0	2.2	0.106	0.02	0.12	2.5	3.9
1997	2.3	0.0	3.1	0.0	3.1	0.090	0.02	0.11	3.5	4.1
1998	4.7	0.0	6.4	0.0	6.4	0.105	0.02	0.12	7.3	4.8
1999	3.8	0.0	5.2	0.0	5.2	0.090	0.02	0.11	5.8	4.2
2000	3.82	0.0	5.2	0.0	5.2	0.079	0.02	0.10	5.7	4.6

Basin:	**Grande Ronde**
Population:	**Lower Grande Ronde**
Sub-population:	Middle Mainstem
Monitoring sites:	**Phillips Creek**
Method:	**Redd Surveys**



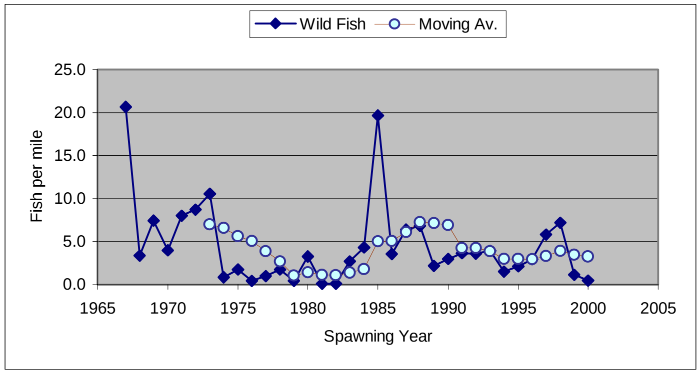
Critical Threshold	0.32
Viable Threshold	0.78
Last 6-yr Average	**2.17**

Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.03	0.00	0.02	0.38	0.44	0.13

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates In-basin	Harvest Rates Combined	Pre- Harv Wild Fish	6- yr Moving Av
1967	5.60	0.00	7.56	0.00	7.56	***0.21***	0.02	0.23	9.8	
1968	1.20	0.00	1.62	0.00	1.62	***0.21***	0.02	0.23	2.1	
1969	4.40	0.00	5.94	0.00	5.94	***0.21***	0.02	0.23	7.7	
1970	2.80	0.00	3.78	0.00	3.78	***0.21***	0.02	0.23	4.9	
1971	2.40	0.00	3.24	0.00	3.24	0.257	0.02	0.27	4.4	
1972	1.20	0.00	1.62	0.00	1.62	0.227	0.02	0.24	2.1	
1973	4.40	0.00	5.94	0.00	5.94	0.301	0.02	0.32	8.7	5.0
1974	0.80	0.00	1.08	0.00	1.08	0.289	0.02	0.30	1.5	4.9
1975	1.60	0.00	2.16	0.00	2.16	0.128	0.02	0.15	2.5	4.0
1976	1.20	0.00	1.62	0.00	1.62	0.067	0.02	0.09	1.8	3.5
1977	2.00	0.00	2.70	0.00	2.70	0.078	0.02	0.10	3.0	3.3
1978	4.00	0.00	5.40	0.00	5.40	0.208	0.02	0.22	7.0	4.1
1979	0.40	0.00	0.54	0.00	0.54	0.196	0.02	0.21	0.7	2.7
1980	5.60	0.00	7.56	0.00	7.56	0.079	0.02	0.10	8.4	3.9
1981	1.20	0.00	1.62	0.00	1.62	0.087	0.02	0.11	1.8	3.8
1982	0.80	0.00	1.08	0.00	1.08	0.069	0.02	0.09	1.2	3.7
1983	0.80	0.00	1.08	0.00	1.08	0.069	0.02	0.09	1.2	3.4
1984	2.56	0.00	3.46	0.00	3.46	0.088	0.02	0.11	3.9	2.9
1985	2.40	0.00	3.24	0.00	3.24	0.121	0.02	0.14	3.8	3.4
1986	4.80	0.00	6.48	0.00	6.48	0.209	0.02	0.23	8.4	3.4
1987	6.00	0.00	8.10	0.00	8.10	0.139	0.02	0.16	9.6	4.7
1988	1.70	0.30	2.30	0.41	2.70	0.158	0.02	0.17	2.8	4.9
1989	1.36	0.24	1.84	0.32	2.16	0.172	0.02	0.19	2.3	5.1
1990	1.70	0.30	2.30	0.41	2.70	0.161	0.02	0.18	2.8	4.9
1991	2.48	0.44	3.35	0.59	3.94	0.160	0.02	0.18	4.1	5.0
1992	5.44	0.96	7.34	1.30	8.64	0.147	0.02	0.16	8.8	5.0
1993	1.36	0.24	1.84	0.32	2.16	0.164	0.02	0.18	2.2	3.8
1994	1.02	0.18	1.38	0.24	1.62	0.155	0.02	0.17	1.7	3.6
1995	1.70	0.30	2.30	0.41	2.70	0.105	0.02	0.12	2.6	3.7
1996	1.36	0.24	1.84	0.32	2.16	0.106	0.02	0.12	2.1	3.6
1997	0.68	0.12	0.92	0.16	1.08	0.090	0.02	0.11	1.0	3.1
1998	2.72	0.48	3.67	0.65	4.32	0.105	0.02	0.12	4.2	2.3
1999	1.36	0.24	1.84	0.32	2.16	0.090	0.02	0.11	2.1	2.3
2000	0.68	0.12	0.92	0.16	1.08	0.079	0.02	0.10	1.0	2.2

Basin:	**Grande Ronde**
Population:	**Upper G. Ronde**
Sub-population:	Upper Mainstem
Monitoring sites:	**McCoy Creek** **Meadows Creek**
Method:	**Redd Surveys**



Critical Threshold	0.13
Viable Threshold	0.45
Last 6-yr Average	**3.28**

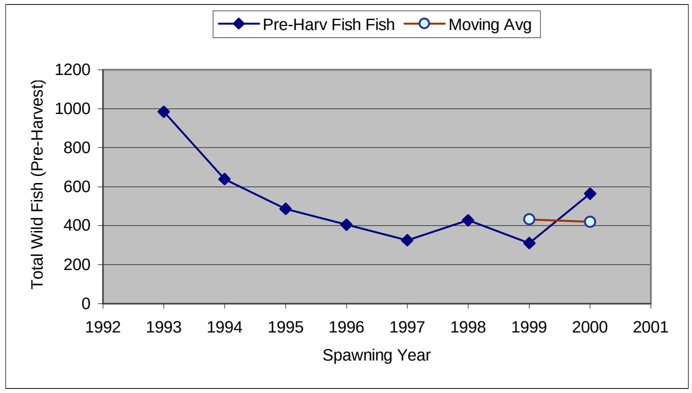
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.03	0.00	0.02	0.38	0.44	0.13

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates In-basin	Harvest Rates Combined	Pre- Harv Wild Fish	6 year Moving Av.
1967	11.8	0.0	15.96	0.00	15.96	***0.21***	0.02	0.23	20.6	
1968	1.9	0.0	2.61	0.00	2.61	***0.21***	0.02	0.23	3.4	
1969	4.3	0.0	5.74	0.00	5.74	***0.21***	0.02	0.23	7.4	
1970	2.3	0.0	3.08	0.00	3.08	***0.21***	0.02	0.23	4.0	
1971	4.3	0.0	5.83	0.00	5.83	0.257	0.02	0.27	8.0	
1972	4.9	0.0	6.61	0.00	6.61	0.227	0.02	0.24	8.7	
1973	5.4	0.0	7.23	0.00	7.23	0.301	0.02	0.32	10.6	7.0
1974	0.4	0.0	0.58	0.00	0.58	0.289	0.02	0.30	0.8	6.6
1975	1.1	0.0	1.49	0.00	1.49	0.128	0.02	0.15	1.7	5.6
1976	0.3	0.0	0.38	0.00	0.38	0.067	0.02	0.09	0.4	5.0
1977	0.7	0.0	0.92	0.00	0.92	0.078	0.02	0.10	1.0	3.9
1978	1.0	0.0	1.35	0.00	1.35	0.208	0.02	0.22	1.7	2.7
1979	0.3	0.0	0.34	0.00	0.34	0.196	0.02	0.21	0.4	1.0
1980	2.2	0.0	2.94	0.00	2.94	0.079	0.02	0.10	3.3	1.4
1981	0.1	0.0	0.07	0.00	0.07	0.087	0.02	0.11	0.1	1.2
1982	0.1	0.0	0.09	0.00	0.09	0.069	0.02	0.09	0.1	1.1
1983	1.8	0.0	2.46	0.00	2.46	0.069	0.02	0.09	2.7	1.4
1984	2.8	0.0	3.83	0.00	3.83	0.088	0.02	0.11	4.3	1.8
1985	12.5	0.0	16.93	0.00	16.93	0.121	0.02	0.14	19.6	5.0
1986	2.0	0.0	2.75	0.00	2.75	0.209	0.02	0.23	3.5	5.1
1987	4.0	0.0	5.40	0.00	5.40	0.139	0.02	0.16	6.4	6.1
1988	3.7	0.5	4.97	0.68	5.64	0.158	0.02	0.17	6.8	7.2
1989	1.2	0.2	1.57	0.21	1.78	0.172	0.02	0.19	2.2	7.2
1990	1.6	0.2	2.16	0.29	2.46	0.161	0.02	0.18	3.0	6.9
1991	1.7	0.5	2.31	0.69	2.99	0.160	0.02	0.18	3.6	4.3
1992	1.7	0.5	2.30	0.69	2.99	0.147	0.02	0.16	3.6	4.3
1993	1.8	0.6	2.49	0.74	3.23	0.164	0.02	0.18	3.9	3.9
1994	0.7	0.2	0.97	0.29	1.26	0.155	0.02	0.17	1.5	3.0
1995	1.1	0.3	1.45	0.43	1.88	0.105	0.02	0.12	2.1	3.0
1996	1.5	0.4	1.97	0.59	2.56	0.106	0.02	0.12	2.9	3.0
1997	3.0	0.9	4.01	1.20	5.20	0.090	0.02	0.11	5.8	3.3
1998	3.6	1.1	4.86	1.45	6.32	0.105	0.02	0.12	7.2	3.9
1999	0.6	0.2	0.78	0.23	1.01	0.090	0.02	0.11	1.1	3.5
2000	0.24	0.07	0.32	0.10	0.42	0.079	0.02	0.10	0.5	3.3

Basin:	**Walla Walla**
Population:	**Walla Walla**
Sub-population:	
Monitoring sites:	**Trap @ Nursery Bridge**
Method:	**Direct counts and mark-recapture estimates**



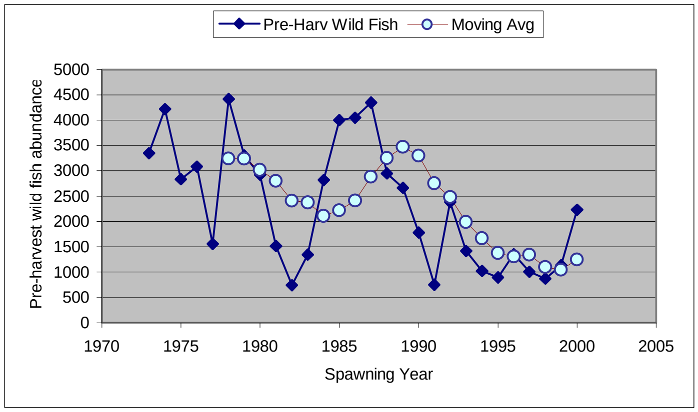
Critical Threshold	
Viable Threshold	
Last 6-yr Average	**419**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	*0.00*	*0.29*	*0.48*	*0.18*	*0.00*

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harvest Rates Out-basin	In-basin	Combined	Pre- Harv re-Harv Fish Fi	Wild Abund 6-yr Moving Avg
1993	815	2	817	0.16	0.010	0.17	985	
1994	535	1	536	0.16	0.010	0.16	640	
1995	430	5	435	0.11	0.010	0.11	485	
1996	358	7	365	0.11	0.010	0.11	404	
1997	292	5	297	0.09	0.010	0.10	324	
1998	378	3	381	0.10	0.010	0.11	426	
1999	279	1	280	0.09	0.010	0.10	310	432
2000	514	13	527	0.08	0.010	0.09	564	419

Basin:	**Umatilla**
Population:	**Umatilla**
Sub-population:	
Monitoring sites:	**Threemile Dam Trap**
Method:	**Total count of returning fish.**



Critical Threshold	140
Viable Threshold	333
Last 6-yr Average	**1247**

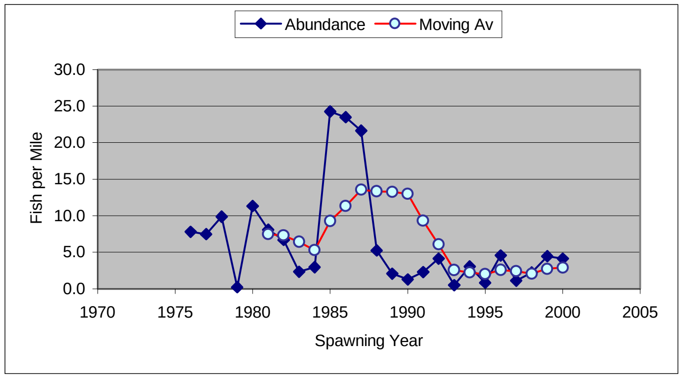
Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.29	0.48	0.18	0.00

Note: Spawner numbers account for wild and hatchery fish removed for broodstock at 3-mile dam - as does pre-harv abundance

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harvest Rates Out-basin	In-basin	Combined	Pre- Harv e-Harv Wild Fi	6-yr Moving Avg
1973	2057	0	2057	0.301	0.12	0.39	3346	
1974	2640	0	2640	0.289	0.12	0.37	4217	
1975	2171	0	2171	0.128	0.12	0.23	2830	
1976	2534	0	2534	0.067	0.12	0.18	3086	
1977	1258	0	1258	0.078	0.12	0.19	1551	
1978	3080	0	3080	0.208	0.12	0.30	4421	3242
1979	2337	0	2337	0.196	0.12	0.29	3304	3235
1980	2367	0	2367	0.079	0.12	0.19	2919	3019
1981	1218	0	1218	0.087	0.12	0.20	1516	2800
1982	608	0	608	0.069	0.12	0.18	742	2409
1983	1103	0	1103	0.069	0.12	0.18	1346	2375
1984	2262	0	2262	0.088	0.12	0.20	2819	2108
1985	3093	0	3093	0.121	0.12	0.23	3998	2223
1986	2816	0	2816	0.209	0.12	0.30	4047	2411
1987	3296	0	3296	0.139	0.12	0.24	4348	2883
1988	2183	166	2349	0.158	0.12	0.26	2946	3251
1989	1944	371	2315	0.172	0.12	0.27	2668	3471
1990	1315	246	1561	0.161	0.12	0.26	1781	3298
1991	625	387	1012	0.160	0.01	0.17	751	2757
1992	2010	523	2533	0.147	0.01	0.16	2381	2479
1993	1172	616	1788	0.164	0.01	0.17	1417	1991
1994	853	345	1198	0.155	0.01	0.16	1020	1669
1995	789	656	1445	0.105	0.01	0.11	890	1373
1996	1196	785	1981	0.106	0.01	0.11	1351	1302
1997	906	1463	2369	0.090	0.01	0.10	1006	1344
1998	773	802	1575	0.105	0.01	0.11	872	1093
1999	1024	661	1685	0.090	0.01	0.10	1136	1046
2000	2032	713	2745	0.079	0.01	0.09	2229	1247

Basin:	**John Day**
Population:	**Lower NF John Day**
Sub-population:	
Monitoring sites:	**Wall Cr** **Wilson Cr**
Method:	**Redd Surveys**



Critical Threshold	0.24
Viable Threshold	0.86
Last 6-yr Average	**2.90**

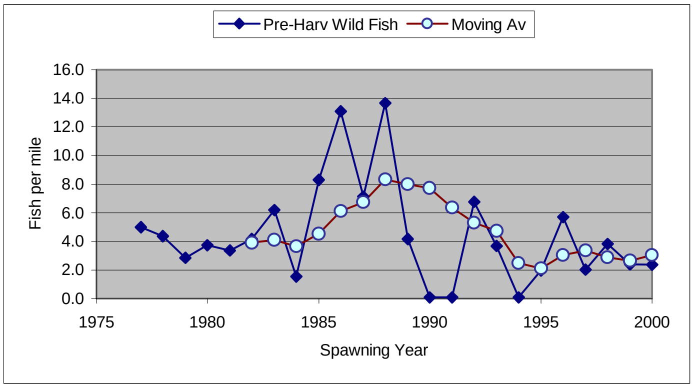
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Sprs	Effective Spawners	Harvest Rates Columbia	Harvest Rates John Day	Harvest Rates Combined	Pre- Harv Abundance	6 year Moving Av
1976	4.75	0.00	6.4	0.0	6.4	0.067	0.12	0.18	7.8	
1977	4.50	0.00	6.1	0.0	6.1	0.078	0.12	0.19	7.5	
1978	5.09	0.00	6.9	0.0	6.9	0.208	0.12	0.30	9.9	
1979	0.12	0.00	0.2	0.0	0.2	0.196	0.12	0.29	0.2	
1980	6.81	0.00	9.2	0.0	9.2	0.079	0.12	0.19	11.3	
1981	4.81	0.00	6.5	0.0	6.5	0.087	0.12	0.20	8.1	7.5
1982	4.06	0.00	5.5	0.0	5.5	0.069	0.12	0.18	6.7	7.3
1983	1.41	0.00	1.9	0.0	1.9	0.069	0.12	0.18	2.3	6.4
1984	1.76	0.00	2.4	0.0	2.4	0.088	0.12	0.20	3.0	5.3
1985	13.90	0.00	18.8	0.0	18.8	0.121	0.12	0.23	24.3	9.3
1986	12.11	0.00	16.4	0.0	16.4	0.209	0.12	0.30	23.5	11.3
1987	12.14	0.00	16.4	0.0	16.4	0.139	0.12	0.24	21.6	13.6
1988	2.87	0.00	3.9	0.0	3.9	0.158	0.12	0.26	5.2	13.3
1989	1.11	0.00	1.5	0.0	1.5	0.172	0.12	0.27	2.1	13.3
1990	0.71	0.00	1.0	0.0	1.0	0.161	0.12	0.26	1.3	13.0
1991	1.36	0.00	1.8	0.0	1.8	0.160	0.04	0.19	2.3	9.3
1992	2.29	0.00	3.1	0.0	3.1	0.147	0.12	0.25	4.1	6.1
1993	0.27	0.00	0.4	0.0	0.4	0.164	0.12	0.26	0.5	2.6
1994	1.85	0.00	2.5	0.0	2.5	0.155	0.04	0.19	3.1	2.2
1995	0.55	0.00	0.7	0.0	0.7	0.105	0.04	0.14	0.9	2.0
1996	3.00	0.00	4.1	0.0	4.1	0.106	0.01	0.11	4.6	2.6
1997	0.75	0.00	1.0	0.0	1.0	0.090	0.01	0.10	1.1	2.4
1998	1.48	0.00	2.0	0.0	2.0	0.105	0.01	0.11	2.2	2.1
1999	2.98	0.00	4.0	0.0	4.0	0.090	0.01	0.10	4.5	2.7
2000	2.80	0.00	3.8	0.0	3.8	0.079	0.01	0.09	4.1	2.9

Basin:	**John Day**
Population:	**Upper NF John Day**
Sub-population:	
Monitoring sites:	**Beaver Cr** **Olive Cr**
Method:	**Redd Surveys**



Critical Threshold	0.12
Viable Threshold	0.46
Last 6-yr Average	**3.04**

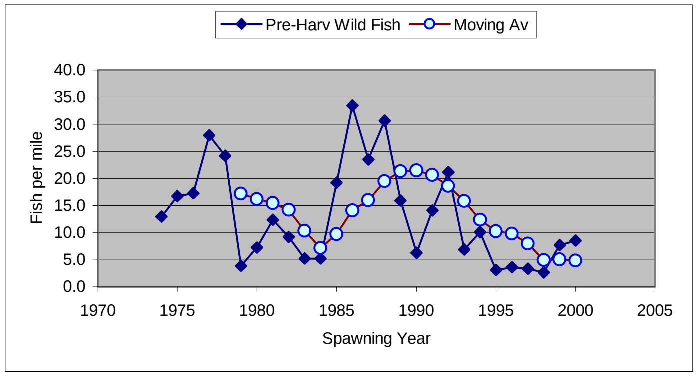
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning	Redds/Mile		Fish/Mile		Effective	Harvest Rates			Pre- Harv	6 year
Year	Wild Fish	Hatch Fish	Wild Spwnrs	Hatch Sprns	Spawners	Columbia	John Day	Combined	e-Harv Wild Fi	Moving Av
1977	3.0	0.0	4.1	0.0	4.1	0.078	0.12	0.19	5.0	
1978	2.3	0.0	3.0	0.0	3.0	0.208	0.12	0.30	4.4	
1979	1.5	0.0	2.0	0.0	2.0	0.196	0.12	0.29	2.9	
1980	2.3	0.0	3.0	0.0	3.0	0.079	0.12	0.19	3.7	
1981	2.0	0.0	2.7	0.0	2.7	0.087	0.12	0.20	3.4	
1982	2.5	0.0	3.4	0.0	3.4	0.069	0.12	0.18	4.2	3.9
1983	3.8	0.0	5.1	0.0	5.1	0.069	0.12	0.18	6.2	4.1
1984	0.9	0.0	1.2	0.0	1.2	0.088	0.12	0.20	1.5	3.6
1985	4.8	0.0	6.4	0.0	6.4	0.121	0.12	0.23	8.3	4.5
1986	6.8	0.0	9.1	0.0	9.1	0.209	0.12	0.30	13.1	6.1
1987	4.0	0.0	5.4	0.0	5.4	0.139	0.12	0.24	7.1	6.7
1988	7.5	0.0	10.1	0.0	10.1	0.158	0.12	0.26	13.7	8.3
1989	2.3	0.0	3.0	0.0	3.0	0.172	0.12	0.27	4.2	8.0
1990	0.1	0.0	0.1	0.0	0.1	0.161	0.12	0.26	0.1	7.7
1991	0.1	0.0	0.1	0.0	0.1	0.160	0.04	0.19	0.1	6.4
1992	3.8	0.0	5.1	0.0	5.1	0.147	0.12	0.25	6.7	5.3
1993	2.0	0.0	2.7	0.0	2.7	0.164	0.12	0.26	3.7	4.7
1994	0.1	0.0	0.1	0.0	0.1	0.155	0.04	0.19	0.1	2.5
1995	1.3	0.0	1.7	0.0	1.7	0.105	0.04	0.14	2.0	2.1
1996	3.8	0.0	5.1	0.0	5.1	0.106	0.01	0.11	5.7	3.0
1997	1.4	0.0	1.8	0.0	1.8	0.090	0.01	0.10	2.0	3.4
1998	2.5	0.0	3.4	0.0	3.4	0.105	0.01	0.11	3.8	2.9
1999	1.6	0.0	2.1	0.0	2.1	0.090	0.01	0.10	2.4	2.7
2000	1.6	0.0	2.1	0.0	2.1	0.079	0.01	0.09	2.4	3.0

Basin:	**John Day**
Population:	**MF John Day**
Sub-population:	
Monitoring sites: (primary)	**Camp Cr** **Lick Cr**
Method:	**Redd Surveys**



Critical Threshold	0.83
Viable Threshold	2.24
Last 6-yr Average	**4.80**

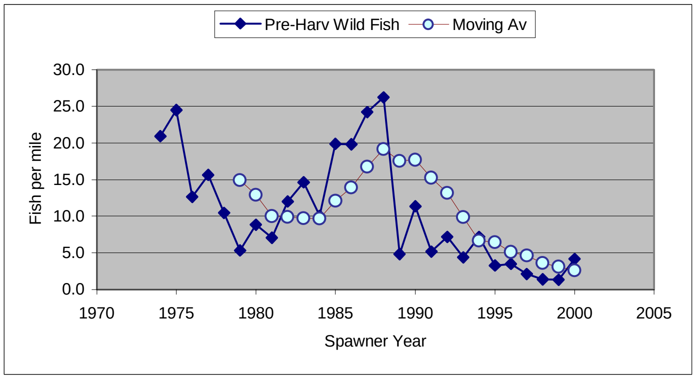
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning	Redds/Mile		Fish/Mile		Effective	Harvest Rates			Pre- Harv	6-year
Year	Wild Fish	Hatch Fish	Wild Spwnrs	Hatch Spnrs	Spawners	Columbia	John Day	Combined	e-Harv Wild Fi	Moving Av
1974	6.0	0.0	8.1	0.0	8.1	0.289	0.12	0.37	12.9	
1975	9.5	0.0	12.8	0.0	12.8	0.128	0.12	0.23	16.7	
1976	10.5	0.0	14.2	0.0	14.2	0.067	0.12	0.18	17.3	
1977	16.8	0.0	22.7	0.0	22.7	0.078	0.12	0.19	27.9	
1978	12.5	0.0	16.9	0.0	16.9	0.208	0.12	0.30	24.2	
1979	2.0	0.0	2.7	0.0	2.7	0.196	0.12	0.29	3.9	17.2
1980	4.3	0.0	5.9	0.0	5.9	0.079	0.12	0.19	7.2	16.2
1981	7.3	0.0	9.9	0.0	9.9	0.087	0.12	0.20	12.3	15.5
1982	5.6	0.0	7.6	0.0	7.6	0.069	0.12	0.18	9.2	14.1
1983	3.2	0.0	4.3	0.0	4.3	0.069	0.12	0.18	5.2	10.3
1984	3.1	0.0	4.2	0.0	4.2	0.088	0.12	0.20	5.2	7.2
1985	11.0	0.0	14.9	0.0	14.9	0.121	0.12	0.23	19.2	9.7
1986	17.2	0.0	23.3	0.0	23.3	0.209	0.12	0.30	33.5	14.1
1987	13.2	0.0	17.8	0.0	17.8	0.139	0.12	0.24	23.5	16.0
1988	16.8	0.0	22.7	0.0	22.7	0.158	0.12	0.26	30.6	19.5
1989	8.6	0.0	11.6	0.0	11.6	0.172	0.12	0.27	15.9	21.3
1990	3.4	0.0	4.6	0.0	4.6	0.161	0.12	0.26	6.3	21.5
1991	8.4	0.0	11.3	0.0	11.3	0.160	0.04	0.19	14.1	20.6
1992	11.8	0.0	15.9	0.0	15.9	0.147	0.12	0.25	21.2	18.6
1993	3.8	0.0	5.1	0.0	5.1	0.164	0.12	0.26	6.9	15.8
1994	6.1	0.0	8.2	0.0	8.2	0.155	0.04	0.19	10.1	12.4
1995	2.0	0.0	2.6	0.0	2.6	0.105	0.04	0.14	3.1	10.3
1996	2.4	0.0	3.2	0.0	3.2	0.106	0.01	0.11	3.6	9.8
1997	2.2	0.0	3.0	0.0	3.0	0.090	0.01	0.10	3.3	8.0
1998	1.7	0.0	2.3	0.0	2.3	0.105	0.01	0.11	2.6	4.9
1999	5.2	0.0	7.0	0.0	7.0	0.090	0.01	0.10	7.7	5.1
2000	5.8	0.0	7.8	0.0	7.8	0.079	0.01	0.09	8.5	4.8

Basin:	**John Day**
Population:	**SF John Day**
Sub-population:	
Monitoring sites: (primary)	**Deer Cr** **Upper Murder's Cr** **Tex Cr**
Method:	**Redd Surveys**



Critical Threshold	0.55
Viable Threshold	1.67
Last 6-yr Average	**2.63**

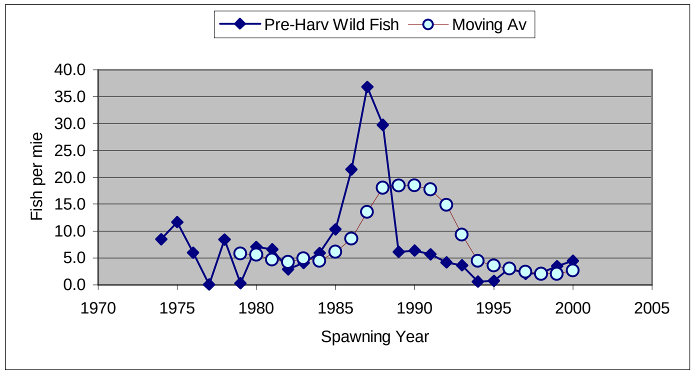
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates John Day	Harvest Rates Combined	Pre- Harv e-Harv Wild Fi	6-year Moving Av
1974	9.7	0.0	13.1	0.0	13.1	0.289	0.12	0.37	20.9	
1975	13.9	0.0	18.8	0.0	18.8	0.128	0.12	0.23	24.5	
1976	7.7	0.0	10.4	0.0	10.4	0.067	0.12	0.18	12.7	
1977	9.4	0.0	12.7	0.0	12.7	0.078	0.12	0.19	15.6	
1978	5.4	0.0	7.3	0.0	7.3	0.208	0.12	0.30	10.5	
1979	2.8	0.0	3.8	0.0	3.8	0.196	0.12	0.29	5.3	14.9
1980	5.3	0.0	7.2	0.0	7.2	0.079	0.12	0.19	8.8	12.9
1981	4.2	0.0	5.7	0.0	5.7	0.087	0.12	0.20	7.1	10.0
1982	7.3	0.0	9.9	0.0	9.9	0.069	0.12	0.18	12.0	9.9
1983	8.9	0.0	12.0	0.0	12.0	0.069	0.12	0.18	14.7	9.7
1984	6.0	0.0	8.1	0.0	8.1	0.088	0.12	0.20	10.1	9.7
1985	11.4	0.0	15.4	0.0	15.4	0.121	0.12	0.23	19.9	12.1
1986	10.2	0.0	13.8	0.0	13.8	0.209	0.12	0.30	19.8	13.9
1987	13.6	0.0	18.4	0.0	18.4	0.139	0.12	0.24	24.2	16.8
1988	14.4	0.0	19.4	0.0	19.4	0.158	0.12	0.26	26.2	19.1
1989	2.6	0.0	3.5	0.0	3.5	0.172	0.12	0.27	4.8	17.5
1990	6.2	0.0	8.4	0.0	8.4	0.161	0.12	0.26	11.3	17.7
1991	3.1	0.0	4.2	0.0	4.2	0.160	0.04	0.19	5.2	15.3
1992	4.0	0.0	5.4	0.0	5.4	0.147	0.12	0.25	7.2	13.2
1993	2.4	0.0	3.2	0.0	3.2	0.164	0.12	0.26	4.4	9.9
1994	4.3	0.0	5.8	0.0	5.8	0.155	0.04	0.19	7.2	6.7
1995	2.1	0.0	2.8	0.0	2.8	0.105	0.04	0.14	3.3	6.4
1996	2.3	0.0	3.1	0.0	3.1	0.106	0.01	0.11	3.5	5.1
1997	1.4	0.0	1.9	0.0	1.9	0.090	0.01	0.10	2.1	4.6
1998	0.9	0.0	1.2	0.0	1.2	0.105	0.01	0.11	1.4	3.6
1999	0.9	0.0	1.2	0.0	1.2	0.090	0.01	0.10	1.3	3.1
2000	2.8	0.0	3.8	0.0	3.8	0.079	0.01	0.09	4.2	2.6

Basin:	**John Day**
Population:	**Lower Mainstem JD**
Sub-population:	
Monitoring sites: (primary)	**Kahler** **Parrish**
Method:	**Redd Surveys**



Critical Threshold	0.24
Viable Threshold	0.79
Last 6-yr Average	**2.68**

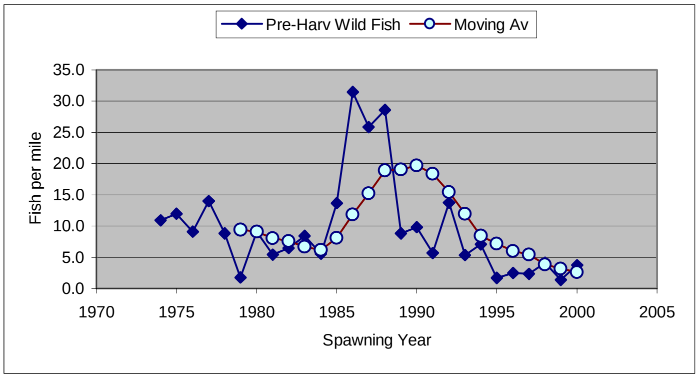
Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates John Day	Harvest Rates Combined	Pre- Harv e-Harv Wild Fi	6-year Moving Av
1974	4.0	0.0	5.3	0.0	5.3	0.289	0.12	0.37	8.5	
1975	6.7	0.0	9.0	0.0	9.0	0.128	0.12	0.23	11.7	
1976	3.6	0.0	4.9	0.0	4.9	0.067	0.12	0.18	6.0	
1977	0.1	0.0	0.1	0.0	0.1	0.078	0.12	0.19	0.1	
1978	4.3	0.0	5.9	0.0	5.9	0.208	0.12	0.30	8.4	
1979	0.2	0.0	0.2	0.0	0.2	0.196	0.12	0.29	0.3	5.8
1980	4.3	0.0	5.7	0.0	5.7	0.079	0.12	0.19	7.1	5.6
1981	3.9	0.0	5.3	0.0	5.3	0.087	0.12	0.20	6.6	4.7
1982	1.8	0.0	2.4	0.0	2.4	0.069	0.12	0.18	2.9	4.2
1983	2.5	0.0	3.4	0.0	3.4	0.069	0.12	0.18	4.1	4.9
1984	3.5	0.0	4.7	0.0	4.7	0.088	0.12	0.20	5.9	4.5
1985	5.9	0.0	8.0	0.0	8.0	0.121	0.12	0.23	10.3	6.1
1986	11.1	0.0	15.0	0.0	15.0	0.209	0.12	0.30	21.5	8.5
1987	20.7	0.0	27.9	0.0	27.9	0.139	0.12	0.24	36.8	13.6
1988	16.3	0.0	22.1	0.0	22.1	0.158	0.12	0.26	29.8	18.1
1989	3.3	0.0	4.5	0.0	4.5	0.172	0.12	0.27	6.2	18.4
1990	3.5	0.0	4.7	0.0	4.7	0.161	0.12	0.26	6.4	18.5
1991	3.4	0.0	4.6	0.0	4.6	0.160	0.04	0.19	5.7	17.7
1992	2.3	0.0	3.2	0.0	3.2	0.147	0.12	0.25	4.2	14.8
1993	2.0	0.0	2.7	0.0	2.7	0.164	0.12	0.26	3.7	9.3
1994	0.4	0.0	0.5	0.0	0.5	0.155	0.04	0.19	0.6	4.5
1995	0.5	0.0	0.7	0.0	0.7	0.105	0.04	0.14	0.8	3.6
1996	2.1	0.0	2.8	0.0	2.8	0.106	0.01	0.11	3.1	3.0
1997	1.35	0.0	1.8	0.0	1.8	0.090	0.01	0.10	2.0	2.4
1998	1.45	0.0	2.0	0.0	2.0	0.105	0.01	0.11	2.2	2.1
1999	2.35	0.0	3.2	0.0	3.2	0.090	0.01	0.10	3.5	2.0
2000	3.0	0.0	4.1	0.0	4.1	0.079	0.01	0.09	4.4	2.7

Basin:	**John Day**
Population:	**Upper Mainstem JD**
Sub-population:	
Monitoring sites: (primary)	**Canyon Cr** **Fields Cr** **Riley Cr** **Bear (Grant Co.)** **Beech Cr** **EF Beech Cr** **McClellan Cr**
Method:	**Redd Surveys**



Critical Threshold	0.50
Viable Threshold	1.54
Last 6-yr Average	**2.62**

Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

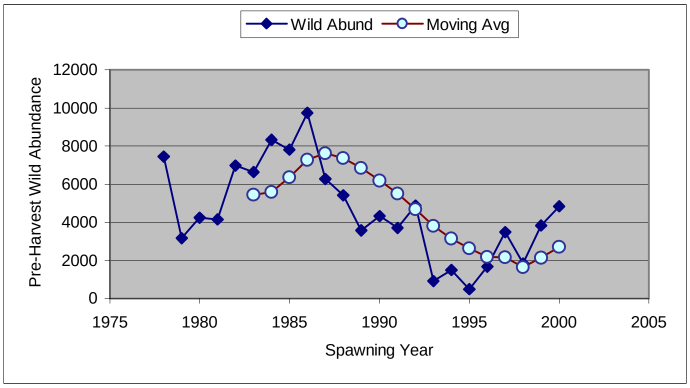
Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.41	0.43	0.11	0.00

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates John Day	Harvest Rates Combined	Pre- Harv e-Harv Wild Fi	6 - year Moving Av
1974	5.1	0.0	6.9	0.0	6.9	0.289	0.12	0.37	10.9	
1975	6.8	0.0	9.2	0.0	9.2	0.128	0.12	0.23	12.0	
1976	5.5	0.0	7.4	0.0	7.4	0.067	0.12	0.18	9.1	
1977	8.4	0.0	11.3	0.0	11.3	0.078	0.12	0.19	14.0	
1978	4.6	0.0	6.2	0.0	6.2	0.208	0.12	0.30	8.8	
1979	0.9	0.0	1.3	0.0	1.3	0.196	0.12	0.29	1.8	9.4
1980	5.5	0.0	7.4	0.0	7.4	0.079	0.12	0.19	9.1	9.1
1981	3.2	0.0	4.4	0.0	4.4	0.087	0.12	0.20	5.4	8.0
1982	3.9	0.0	5.3	0.0	5.3	0.069	0.12	0.18	6.5	7.6
1983	5.1	0.0	6.9	0.0	6.9	0.069	0.12	0.18	8.4	6.7
1984	3.3	0.0	4.5	0.0	4.5	0.088	0.12	0.20	5.6	6.1
1985	7.8	0.0	10.6	0.0	10.6	0.121	0.12	0.23	13.7	8.1
1986	16.2	0.0	21.9	0.0	21.9	0.209	0.12	0.30	31.5	11.8
1987	14.5	0.0	19.6	0.0	19.6	0.139	0.12	0.24	25.9	15.3
1988	15.7	0.0	21.2	0.0	21.2	0.158	0.12	0.26	28.6	18.9
1989	4.8	0.0	6.4	0.0	6.4	0.172	0.12	0.27	8.8	19.0
1990	5.4	0.0	7.2	0.0	7.2	0.161	0.12	0.26	9.8	19.7
1991	3.4	0.0	4.6	0.0	4.6	0.160	0.04	0.19	5.7	18.4
1992	7.7	0.0	10.3	0.0	10.3	0.147	0.12	0.25	13.8	15.4
1993	2.9	0.0	3.9	0.0	3.9	0.164	0.12	0.26	5.3	12.0
1994	4.2	0.0	5.7	0.0	5.7	0.155	0.04	0.19	7.1	8.4
1995	1.1	0.0	1.4	0.0	1.4	0.105	0.04	0.14	1.7	7.2
1996	1.6	0.0	2.2	0.0	2.2	0.106	0.01	0.11	2.5	6.0
1997	1.6	0.0	2.1	0.0	2.1	0.090	0.01	0.10	2.4	5.5
1998	2.7	0.0	3.6	0.0	3.6	0.105	0.01	0.11	4.1	3.8
1999	0.9	0.0	1.3	0.0	1.3	0.090	0.01	0.10	1.4	3.2
2000	2.5	0.0	3.4	0.0	3.4	0.079	0.01	0.09	3.7	2.6

Basin:	**Deschutes**
Population:	**Deschutes**
Sub-population:	
Monitoring sites:	**Sherars Falls**

Methods:
Mark-recapture population estimate from sub-sample of run tagged at Sherars Falls. Recoveries at Pelton and Warm Springs NFH Traps.

Critical Threshold	473
Viable Threshold	1479
Last 6-yr Average	**7395**



Average Distribution of Ages in return year

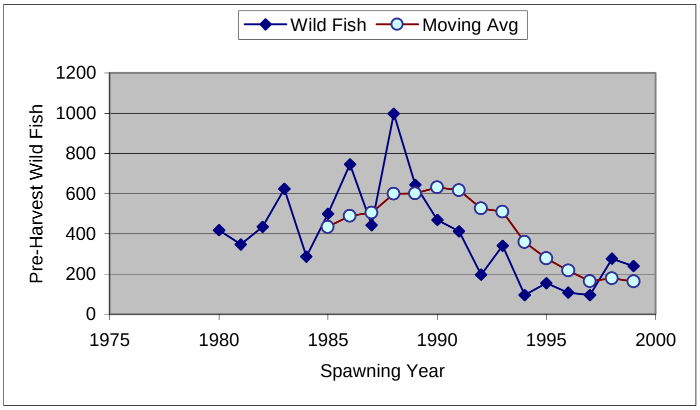
Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.15	0.41	0.33	0.07

Spawning Year	Wild Escapm Pop.Estm	Wild Escapm Wild Spwnrs	RBH	Hatch Strays	Total Spawners	Pre- Harv Wild Abund	Wild Abund 6-yr Moving Avg
1978	6600	5808	3248	237	9293	7446	
1979	2800	2464	1084	0	3548	3159	
1980	4200	4150	2140	157	6447	4243	
1981	4100	4051	2645	129	6825	4142	
1982	6900	6817	1584	266	8668	6971	
1983	6567	6488	1554	396	8439	6634	5432
1984	8228	8129	3941	1253	13323	8312	5577
1985	7721	7628	3377	551	11557	7800	6350
1986	9624	9509	3343	837	13688	9722	7264
1987	6207	6133	5336	1913	13381	6270	7618
1988	5367	5303	6620	2149	14072	5422	7360
1989	3546	3503	2140	724	6368	3582	6852
1990	4278	4227	1598	763	6588	4322	6186
1991	3653	3609	1145	604	5358	3690	5502
1992	4826	4768	1960	2111	8839	4875	4694
1993	904	893	1077	1073	3043	913	3801
1994	1487	1469	830	1228	3527	1502	3148
1995	482	476	814	904	2194	487	2632
1996	1662	1642	1383	3197	6222	1679	2191
1997	3458	3417	1615	6313	11344	3493	2158
1998	1820	1798	1997	3772	7568	1839	1652
1999	3800	3754	1969	2627	8350	3839	2140
2000	4790	4733	1263	4084	10079	4839	2696

Basin:	**Deschutes**
Population:	**Deschutes**
Sub-population:	Warm Springs
Monitoring sites:	**Warm Springs NFH Trap**

Method:
Total count of returning fish. No hatchery fish allowed to pass into Warm Springs River above the trap.

Critical Threshold	33
Viable Threshold	80
Last 6-yr Average	**162**

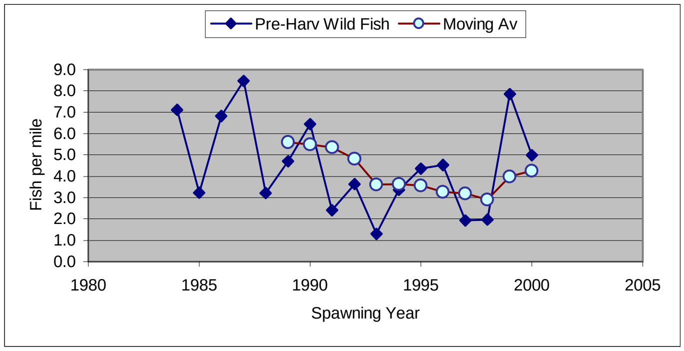


Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.15	0.41	0.33	0.07

Spawning Year	Spawners Wild	Spawners Hatchery	Total Spawners	Hr above Shearars	Hr below Sherars	Columbia Mainst HR	overall **Harv Rate**	Pre- Harv Wild Fish	6-yr Moving Avg
1980	378	0.0	378	0.01	0.01	0.079	0.097	419	
1981	311	0.0	311	0.01	0.01	0.087	0.105	348	
1982	397	0.0	397	0.01	0.01	0.069	0.088	435	
1983	569	0.0	569	0.01	0.01	0.069	0.088	624	
1984	255	0.0	255	0.01	0.01	0.088	0.106	285	
1985	431	0.0	431	0.01	0.01	0.121	0.138	500	435
1986	577	0.0	577	0.01	0.01	0.209	0.225	744	489
1987	373	0.0	373	0.01	0.01	0.139	0.156	442	505
1988	822	0.0	822	0.01	0.01	0.158	0.175	996	599
1989	522	0.0	522	0.01	0.01	0.172	0.188	643	602
1990	385	0.0	385	0.01	0.01	0.161	0.178	468	632
1991	339	0.0	339	0.01	0.01	0.160	0.177	412	618
1992	165	0.0	165	0.01	0.01	0.147	0.164	197	526
1993	280	0.0	280	0.01	0.01	0.164	0.181	342	510
1994	79	0.0	79	0.01	0.01	0.155	0.172	95	360
1995	135	0.0	135	0.01	0.01	0.105	0.123	154	278
1996	95	0.0	95	0.01	0.01	0.106	0.124	108	218
1997	85	0.0	85	0.01	0.01	0.090	0.108	95	165
1998	243	0.0	243	0.01	0.01	0.105	0.123	277	179
1999	214	0.0	214	0.01	0.01	0.090	0.108	240	162

Basin:	**Fifteenmile**
Population:	**Fifteenmile**
Sub-population:	
Monitoring sites:	**Fifteenmile Creek**
Method:	**Redd Surveys**



Critical Threshold	
Viable Threshold	
Last 6-yr Average	**4.3**

Females per Redd =	0.81
Prop. of females in spng pop. =	0.60

Average Distribution of Ages in return year

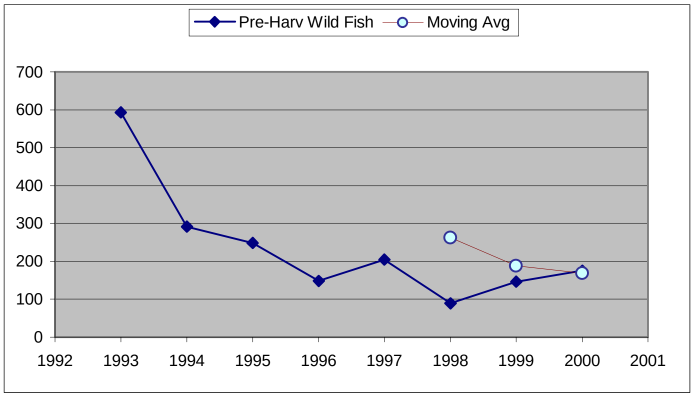
Estimates based upon observations for Hood River winter steelhead.

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	0.00	0.07	0.60	0.25	0.02

Spawning Year	Redds/Mile Wild Fish	Redds/Mile Hatch Fish	Fish/Mile Wild Spwnrs	Fish/Mile Hatch Spnrs	Effective Spawners	Harvest Rates Columbia	Harvest Rates Fifteenm	Harvest Rates Combined	Pre- Harv e-Harv Wild Fi	6-year Moving Av
1984	4.8	0.0	6.5	0.0	6.5	0.088	0.00	0.09	7.1	
1985	2.1	0.0	2.8	0.0	2.8	0.121	0.00	0.12	3.2	
1986	4.0	0.0	5.4	0.0	5.4	0.209	0.00	0.21	6.8	
1987	5.4	0.0	7.3	0.0	7.3	0.139	0.00	0.14	8.5	
1988	2.0	0.0	2.7	0.0	2.7	0.158	0.00	0.16	3.2	
1989	***2.9***	0.0	3.9	0.0	3.9	0.172	0.00	0.17	4.7	5.6
1990	4.0	0.0	5.4	0.0	5.4	0.161	0.00	0.16	6.4	5.5
1991	1.5	0.0	2.0	0.0	2.0	0.160	0.00	0.16	2.4	5.3
1992	2.3	0.0	3.1	0.0	3.1	0.147	0.00	0.15	3.6	4.8
1993	0.8	0.0	1.1	0.0	1.1	0.164	0.00	0.16	1.3	3.6
1994	2.1	0.0	2.8	0.0	2.8	0.155	0.00	0.16	3.4	3.6
1995	***2.9***	0.0	3.9	0.0	3.9	0.105	0.00	0.11	4.4	3.6
1996	3.0	0.0	4.1	0.0	4.1	0.106	0.00	0.11	4.5	3.3
1997	1.3	0.0	1.8	0.0	1.8	0.090	0.00	0.09	1.9	3.2
1998	1.3	0.0	1.8	0.0	1.8	0.105	0.00	0.11	2.0	2.9
1999	5.3	0.0	7.2	0.0	7.2	0.090	0.00	0.09	7.9	4.0
2000	3.4	0.0	4.6	0.0	4.6	0.079	0.00	0.08	5.0	4.3

Basin:	**Hood River**
Population:	**Hood River StS**
Sub-population:	
Monitoring sites:	**Powerdale Dam Trap**
Method:	**Total count of returning fish.**

Critical Threshold	
Viable Threshold	
Last 6-yr Average	**169**



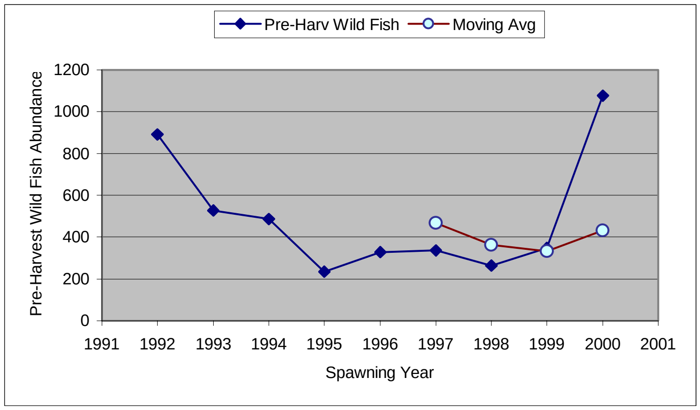
Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	*0.00*	*0.08*	*0.56*	*0.29*	*0.02*

Note: Some wild fish removed for hatchery broodstock development program and in recent years most, if not all hatchery fish prevented from passing upstream

Spawning	Wild Fish		Hatchery Fish		Effective	Wild Fish Harvest Rates			Pre- Harv	6-yr
Year	counted	escapem	counted	escapem	Tot. Spwnrs	Out-basin	In-basin	Combined	e-Harv Wild Fi	Moving Avg
1993	491	491	1730	1723	2214	0.164	0.010	0.17	593	
1994	244	242	1112	1106	1348	0.155	0.010	0.16	292	
1995	220	219	1539	1634	1853	0.105	0.010	0.11	248	
1996	132	131	553	522	653	0.106	0.010	0.11	149	
1997	184	179	1389	1315	1494	0.090	0.010	0.10	204	
1998	79	64	600	449	513	0.105	0.010	0.11	89	263
1999	132	100	567	4	104	0.090	0.010	0.10	146	188
2000	160	126	465	1	127	0.079	0.010	0.09	175	169

Basin:	**Hood River**
Population:	**Hood River StW**
Sub-population:	
Monitoring sites:	**Powerdale Dam Trap**
Method:	**Total count of returning fish.**



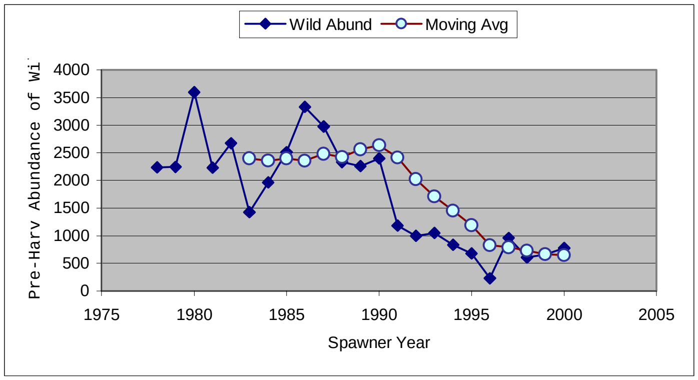
Critical Threshold	
Viable Threshold	
Last 6-yr Average	**431**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.05	*0.00*	*0.07*	*0.60*	*0.25*	*0.02*

Spawning	Wild Fish		Hatchery Fish		Effective	Wild Fish Harvest Rates			Pre- Harv	6-yr
Year	counted	escapem	counted	escapem	Tot. Spwnrs	Out-basin	In-basin	Combined	e-Harv Wild Fi	Moving Avg
1992	699	621	318	281	902	0.147	0.010	0.22	892	
1993	412	343	238	11	354	0.164	0.010	0.22	527	
1994	405	301	176	5	306	0.155	0.010	0.17	488	
1995	206	161	111	5	166	0.105	0.010	0.12	235	
1996	280	211	280	162	373	0.106	0.010	0.15	328	
1997	289	239	641	254	493	0.090	0.010	0.14	336	468
1998	227	182	393	164	346	0.105	0.010	0.14	263	363
1999	301	258	323	200	458	0.090	0.010	0.14	349	333
2000	930	876	299	200	1076	0.079	0.010	0.14	1077	431

Basin: **Sandy**
Population: **Sandy**
Sub-population:
Monitoring sites: **Marmot Dam**
Method: **Counts estimated from video pictures at ladder until 1998. from 1998 to present fish have been trapped and directly counted. Likewise for identification hatchery fish; prior to 1998 identification was based upon run timing (hatchery fish earlier than wild).**



Critical Threshold	76
Viable Threshold	336
Last 6-yr Average	**651**

Note: Wild fish removed for hatchery broodstock development. Also hatchery fish prevented from passing upstream of trap site starting in 1999.

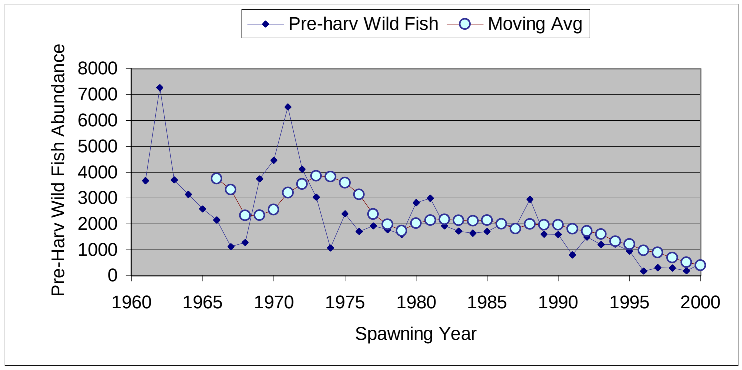
Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.11	0.00	0.01	0.63	0.23	0.02

Spawning Year	wild count	wild fish removed	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harvest Rates Out-basin	In-basin	Combined	Pre- Harv Wild Abund	6-yr Moving Avg
1978	1342		1342	2729	4071	0.00	0.40	0.40	2237	
1979	1344		1344	656	2000	0.00	0.40	0.40	2240	
1980	2157		2157	858	3015	0.00	0.40	0.40	3595	
1981	1338		1338	2740	4078	0.00	0.40	0.40	2230	
1982	1602		1602	1087	2689	0.00	0.40	0.40	2670	
1983	856		856	1593	2449	0.00	0.40	0.40	1427	2400
1984	1176		1176	1056	2232	0.00	0.40	0.40	1960	2354
1985	1505		1505	1336	2841	0.00	0.40	0.40	2508	2398
1986	1995		1995	757	2752	0.00	0.40	0.40	3325	2353
1987	1785		1785	1890	3675	0.00	0.40	0.40	2975	2478
1988	1401		1401	2039	3440	0.00	0.40	0.40	2335	2422
1989	1356		1356	1637	2993	0.00	0.40	0.40	2260	2561
1990	1438		1438	1627	3065	0.00	0.40	0.40	2397	2633
1991	707		707	1288	1995	0.00	0.40	0.40	1178	2412
1992	956		956	1962	2918	0.00	0.04	0.04	996	2023
1993	1008		1008	628	1636	0.00	0.04	0.04	1050	1703
1994	802		802	765	1567	0.00	0.04	0.04	835	1453
1995	653		653	1027	1680	0.00	0.04	0.04	680	1189
1996	220		220	316	536	0.00	0.04	0.04	229	828
1997	924		924	474	1398	0.00	0.04	0.040	963	792
1998	584		584	359	943	0.00	0.04	0.040	608	728
1999	629		629	0	629	0.00	0.04	0.040	655	662
2000	741	123	618	0	618	0.00	0.04	0.040	772	651

Basin: **Clackamas**
Population: **Clackamas**
Sub-population:
Monitoring sites: **NF Dam**
Method: **Counts estimated from video pictures at ladder until 1997. from 1998 to present fish have been trapped and directly counted. In addition, for identification of hatchery fish; prior to 1996 identification was based upon run timing (hatchery fish earlier than wild).**

Critical Threshold	71
Viable Threshold	279
Last 6-yr Average	**395**



Average Distribution of Ages in return year

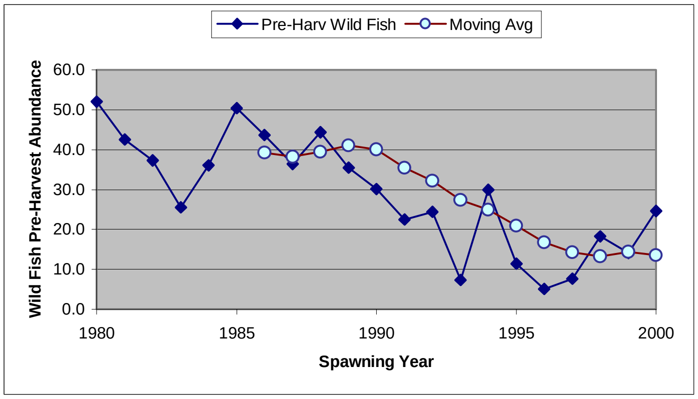
Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.11	0.00	0.01	0.63	0.23	0.02

Note: Wild fish removed for hatchery broodstock development. Also hatchery fish prevented from passing upstream of trap site starting in 1999

Spawning Year	wild count	removed	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Harvest Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1961	2203		2203	1	2204	0.40	3672	
1962	4359		4359	2	4361	0.40	7265	
1963	2223		2223	14	2237	0.40	3705	
1964	1881		1881	1	1882	0.40	3135	
1965	1544		1544	8	1552	0.40	2573	
1966	1287		1287	3	1290	0.40	2145	3749
1967	676		676	6	682	0.40	1127	3325
1968	767		767	23	790	0.40	1278	2327
1969	2245		2245	71	2316	0.40	3742	2333
1970	2673		2673	136	2809	0.40	4455	2553
1971	3908		3908	441	4349	0.40	6513	3210
1972	2466		2466	168	2634	0.40	4110	3538
1973	1816		1816	81	1897	0.40	3027	3854
1974	641		641	30	671	0.40	1068	3819
1975	1431		1431	95	1526	0.40	2385	3593
1976	1025		1025	157	1182	0.40	1708	3135
1977	1156		1156	371	1527	0.40	1927	2371
1978	1067		1067	920	1987	0.40	1778	1982
1979	950		950	561	1511	0.40	1583	1742
1980	1693		1693	372	2065	0.40	2822	2034
1981	1798		1798	899	2697	0.40	2997	2136
1982	1153		1153	293	1446	0.40	1922	2171
1983	1031		1031	68	1099	0.40	1718	2137
1984	987		987	251	1238	0.40	1645	2114
1985	1027		1027	198	1225	0.40	1712	2136
1986	1194		1194	238	1432	0.40	1990	1997
1987	1139		1139	179	1318	0.40	1898	1814
1988	1773		1773	347	2120	0.40	2955	1986
1989	963		963	288	1251	0.40	1605	1968
1990	953		953	534	1487	0.40	1588	1958
1991	482	43	439	355	794	0.40	803	1807
1992	1430	40	1390	677	2067	0.04	1490	1723
1993	1155	35	1120	197	1317	0.04	1203	1607
1994	1169	30	1139	78	1217	0.04	1218	1318
1995	913	34	879	233	1112	0.04	951	1209
1996	161	21	140	148	288	0.04	168	972
1997	291	22	269	239	508	0.04	303	889
1998	285	20	265	219	484	0.04	297	690
1999	177	25	152	12	164	0.04	184	520
2000	447	36	386	1	387	0.04	466	395

Basin:	**Molalla**
Population:	**Molalla**
Sub-population:	
Monitoring sites:	**Index sites**
Method:	**Redd Surveys**

Critical Threshold	2.50
Viable Threshold	9.90
Last 6-yr Average	**13.56**

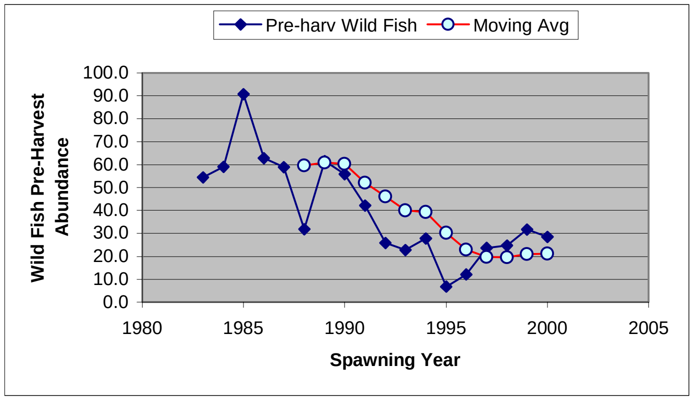


Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.00	0.83	0.07	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv e-Harv Wild Fi	Wild Abund 6-yr Moving Avg
1980	41.1	35.0	76.1	0.21	52.0	
1981	33.6	28.6	62.2	0.21	42.5	
1982	29.5	25.1	54.6	0.21	37.3	
1983	20.2	17.2	37.4	0.21	25.6	
1984	28.5	24.3	52.8	0.21	36.1	
1985	39.8	33.9	73.7	0.21	50.3	
1986	34.5	29.4	63.9	0.21	43.7	39.3
1987	28.8	24.5	53.3	0.21	36.4	38.2
1988	35.0	29.9	64.9	0.21	44.4	39.4
1989	28.0	23.9	51.9	0.21	35.5	41.1
1990	23.8	20.3	44.1	0.21	30.1	40.1
1991	17.8	15.1	32.9	0.21	22.5	35.4
1992	24.0	7.2	31.1	0.02	24.5	32.2
1993	7.2	2.3	9.4	0.02	7.3	27.4
1994	29.3	9.3	38.6	0.02	29.9	25.0
1995	11.2	3.6	14.8	0.02	11.5	21.0
1996	5.1	1.6	6.6	0.02	5.2	16.8
1997	7.5	2.4	9.9	0.02	7.7	14.3
1998	17.9	5.4	23.3	0.02	18.3	13.3
1999	13.9	4.1	18.0	0.02	14.1	14.4
2000	24.1	0.5	24.6	0.02	24.6	13.6

Basin:	**Santiam**
Population:	**North Santiam**
Sub-population:	
Monitoring sites:	**Index Sites**
Method:	**Redd counts**



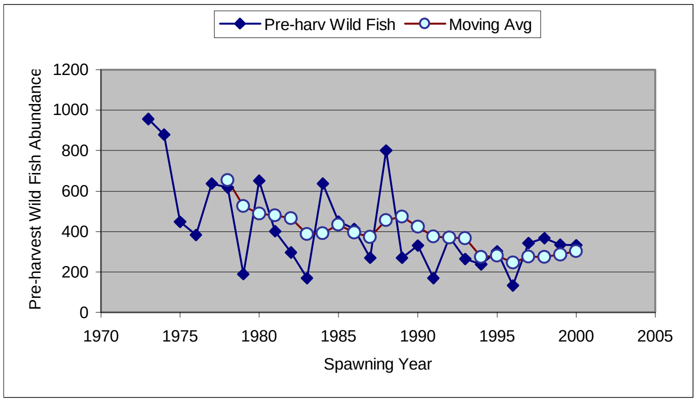
Critical Threshold	9.8
Viable Threshold	16.4
Last 6-yr Average	**21.2**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.00	0.83	0.07	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1983	43.1	7.5	50.5	0.21	54.5	
1984	46.7	8.1	54.8	0.21	59.1	
1985	71.7	12.4	84.1	0.21	90.7	
1986	49.6	8.6	58.2	0.21	62.8	
1987	46.5	8.1	54.6	0.21	58.9	
1988	25.1	4.4	29.5	0.21	31.8	59.6
1989	48.6	8.4	57.1	0.21	61.5	60.8
1990	44.1	7.7	51.8	0.21	55.9	60.3
1991	33.3	5.8	39.1	0.21	42.2	52.2
1992	25.3	4.4	29.7	0.02	25.8	46.0
1993	22.4	4.4	26.7	0.02	22.8	40.0
1994	27.2	4.1	31.3	0.02	27.7	39.3
1995	6.7	0.8	7.5	0.02	6.8	30.2
1996	11.8	1.5	13.3	0.02	12.0	22.9
1997	23.2	2.3	25.4	0.02	23.6	19.8
1998	24.2	10.1	34.2	0.02	24.7	19.6
1999	31.0	11.2	42.2	0.02	31.6	21.1
2000	27.9	3.9	31.8	0.02	28.4	21.2

Basin:	**Santiam**
Population:	**Upper S. Santiam**
Sub-population:	
Monitoring sites:	**Foster Dam Trap**
Method:	**Total count of returning fish.**



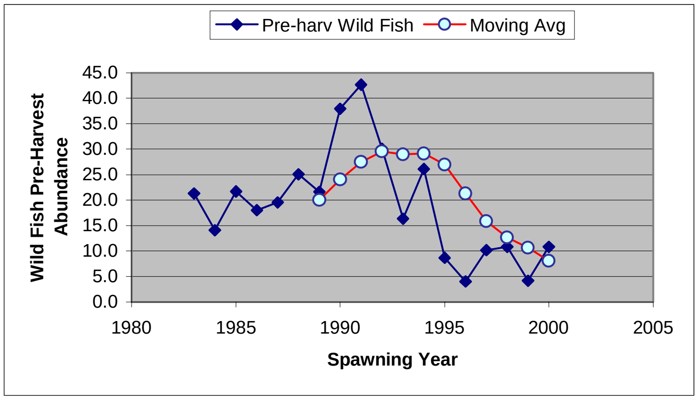
Critical Threshold	30
Viable Threshold	108
Last 6-yr Average	**302**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.00	0.83	0.07	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1973	755	0	755	0.21	956	
1974	695	0	695	0.21	880	
1975	354	0	354	0.21	448	
1976	302	0	302	0.21	382	
1977	503	0	503	0.21	637	
1978	488	0	488	0.21	618	653
1979	149	0	149	0.21	189	526
1980	515	0	515	0.21	652	488
1981	317	0	317	0.21	401	480
1982	234	165	399	0.21	296	465
1983	134	66	200	0.21	170	388
1984	504	993	1497	0.21	638	391
1985	355	629	984	0.21	449	434
1986	326	485	811	0.21	413	395
1987	214	253	467	0.21	271	373
1988	656	423	1079	0.18	800	457
1989	222	62	284	0.18	271	474
1990	272	10	282	0.18	332	423
1991	139	0	139	0.18	170	376
1992	361	0	361	0.03	372	369
1993	256	0	256	0.03	264	368
1994	234	0	234	0.02	239	274
1995	297	0	297	0.02	303	280
1996	131	0	131	0.02	134	247
1997	336	0	336	0.02	343	276
1998	359	0	359	0.02	366	275
1999	328	0	328	0.02	335	287
2000	326	0	326	0.02	333	302

Basin:	**Santiam**
Population:	**Lower S. Santiam**
Sub-population:	
Monitoring sites:	**Index sites**
Method:	**Redd Counts**



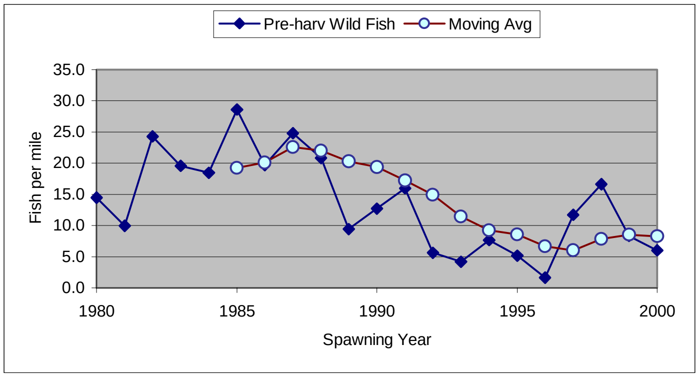
Critical Threshold	2.10
Viable Threshold	8.10
Last 6-yr Average	**8.09**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.00	0.83	0.07	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv Pre-harv Wild Fi	6-yr Moving Avg
1983	16.8	8.3	25	0.21	21.3	
1984	11.1	21.9	33	0.21	14.1	
1985	17.2	30.4	48	0.21	21.7	
1986	14.2	21.2	35	0.21	18.0	
1987	15.5	18.3	34	0.21	19.6	
1988	19.8	12.8	33	0.21	25.1	
1989	17.1	4.8	22	0.21	21.6	20.0
1990	30.0	1.1	31	0.21	38.0	24.0
1991	33.7	0.0	34	0.21	42.7	27.5
1992	29.5	0.0	30	0.02	30.1	29.5
1993	16.0	0.0	16	0.02	16.3	29.0
1994	25.6	0.0	26	0.02	26.1	29.1
1995	8.5	0.0	8	0.02	8.6	27.0
1996	3.9	0.0	4	0.02	4.0	21.3
1997	9.9	0.0	10	0.02	10.1	15.9
1998	10.6	0.0	11	0.02	10.8	12.7
1999	4.1	0.0	4	0.02	4.2	10.6
2000	10.6	0.0	11	0.02	10.8	8.1

Basin:	**Calapooia**
Population:	**Calapooia**
Sub-population:	
Monitoring sites:	**Index sites**
Method:	**Redd Surveys**



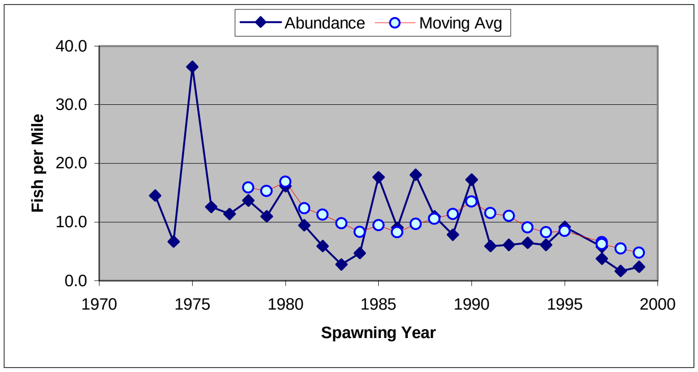
Critical Threshold	0.70
Viable Threshold	2.20
Last 6-yr Average	**8.25**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.00	0.83	0.07	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1980	13.0	0.0	13.0	0.10	14.5	
1981	9.0	0.0	9.0	0.10	10.0	
1982	21.8	0.0	21.8	0.10	24.3	
1983	17.6	0.0	17.6	0.10	19.6	
1984	16.6	0.0	16.6	0.10	18.5	
1985	25.8	0.0	25.8	0.10	28.6	19.2
1986	17.7	0.0	17.7	0.10	19.7	20.1
1987	22.3	0.0	22.3	0.10	24.8	22.6
1988	18.7	0.0	18.7	0.10	20.8	22.0
1989	8.5	0.0	8.5	0.10	9.4	20.3
1990	11.4	0.0	11.4	0.10	12.7	19.3
1991	14.3	0.0	14.3	0.1	15.9	17.2
1992	5.5	0.0	5.5	0.02	5.7	14.9
1993	4.1	0.0	4.1	0.02	4.2	11.4
1994	7.5	0.0	7.5	0.02	7.7	9.2
1995	5.1	0.0	5.1	0.02	5.2	8.5
1996	1.6	0.0	1.6	0.02	1.7	6.7
1997	11.7	0.0	11.7	0.00	11.7	6.0
1998	16.6	0.0	16.6	0.00	16.6	7.8
1999	8.3	0.0	8.3	0.00	8.3	8.5
2000	6.0	0.0	6.0	0.00	6.0	8.3

Basin:	**Nehalem**
Population:	**Salmonberry**
Sub-population:	
Monitoring sites:	**Enright Mainstem Site**
Method:	**Spawning Survey Counts of Observed Fish**



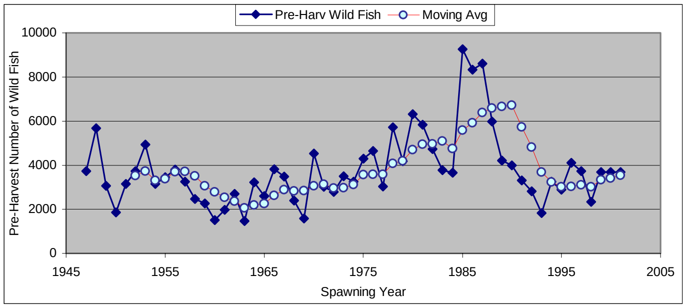
Critical Threshold	0.44
Viable Threshold	1.44
Last 6-yr Average	**4.80**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.15	0.00	0.09	0.64	0.11	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv Abundance	6-yr Moving Avg
1973	12.3	0.0	12.3	0.15	14.5	
1974	5.7	0.0	5.7	0.15	6.7	
1975	31.0	0.0	31.0	0.15	36.5	
1976	10.7	0.0	10.7	0.15	12.5	
1977	9.7	0.0	9.7	0.15	11.4	
1978	11.6	0.0	11.6	0.15	13.7	15.9
1979	9.3	0.0	9.3	0.15	11.0	15.3
1980	13.7	0.0	13.7	0.15	16.1	16.9
1981	8.0	0.0	8.0	0.15	9.4	12.3
1982	5.0	0.0	5.0	0.15	5.9	11.2
1983	2.3	0.0	2.3	0.15	2.7	9.8
1984	4.0	0.0	4.0	0.15	4.7	8.3
1985	15.0	0.0	15.0	0.15	17.6	9.4
1986	7.7	0.0	7.7	0.15	9.0	8.2
1987	15.3	0.0	15.3	0.15	18.0	9.7
1988	9.3	0.0	9.3	0.15	11.0	10.5
1989	6.7	0.0	6.7	0.15	7.8	11.4
1990	14.7	0.0	14.7	0.15	17.3	13.5
1991	5.0	0.0	5.0	0.15	5.9	11.5
1992	6.0	0.0	6.0	0.02	6.1	11.0
1993	6.3	0.0	6.3	0.02	6.5	9.1
1994	6.0	0.0	6.0	0.02	6.1	8.3
1995	9.0	0.0	9.0	0.02	9.2	8.5
1997	5.7	0.0	5.7	0.02	5.8	6.6
1997	3.7	0.0	3.7	0.02	3.7	6.2
1998	1.7	0.0	1.7	0.02	1.7	5.5
1999	2.3	0.0	2.3	0.02	2.3	4.8

Basin:	**Umpqua**
Population:	**NFork Summer Sthd**
Sub-population:	
Monitoring sites:	**Winchester Dam**
Method:	**Fish Counts at Dam**



Critical Threshold	174
Viable Threshold	647
Last 6-yr Average	**3546**

Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.00	0.01	0.25	0.43	0.21

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish e-Harv Wild Fi	6-yr Moving Avg
1947	2241	0	2241	3734	
1948	3409	0	3409	5681	
1949	1841	0	1841	3069	
1950	1115	0	1115	1858	
1951	1890	0	1890	3150	
1952	2241	0	2241	3734	3538
1953	2962	0	2962	4937	3738
1954	1896	0	1896	3160	3318
1955	2078	0	2078	3463	3384
1956	2287	0	2287	3811	3709
1957	1951	0	1951	3252	3726
1958	1485	0	1485	2476	3516
1959	1361	0	1361	2268	3072
1960	904	32	936	1507	2796
1961	1188	43	1231	1980	2549
1962	1625	32	1657	2708	2365
1963	879	54	933	1464	2067
1964	1938	88	2026	3230	2193
1965	1560	26	1586	2600	2248
1966	2297	91	2387	3828	2635
1967	2093	139	2232	3488	2886
1968	1440	122	1562	2400	2835
1969	953	171	1125	1589	2856
1970	2723	496	3219	4538	3074
1971	1818	588	2406	3030	3145
1972	1673	626	2298	2788	2972
1973	2106	484	2590	3510	2976
1974	1955	282	2237	3258	3119
1975	2583	208	2791	4306	3571

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish e-Harv Wild Fi	6-yr Moving Avg
1976	2793	227	3019	4654	3591
1977	1824	182	2006	3040	3593
1978	3435	210	3645	5726	4082
1979	2511	257	2768	4184	4195
1980	3793	240	4033	6321	4705
1981	3508	230	3738	5847	4962
1982	2845	94	2939	4741	4976
1983	2265	101	2366	3774	5099
1984	2201	41	2242	3668	4756
1985	5555	266	5821	9259	5602
1986	4999	350	5350	8332	5937
1987	5162	549	5711	8603	6396
1988	3592	702	4294	5987	6604
1989	2533	527	3061	4222	6679
1990	2401	407	2809	4002	6734
1991	1991	347	2338	3318	5744
1992	2450	107	2557	2816	4825
1993	1595	97	1692	1833	3696
1994	2833	114	2947	3257	3241
1995	2512	97	2609	2888	3019
1996	3573	124	3697	4107	3036
1997	3249	182	3431	3734	3106
1998	2039	270	2309	2343	3027
1999	3216	266	3482	3697	3338
2000	2600	124	2724	3697	3411
2001	3867	275	4141	3697	3546

Basin: **Umpqua**

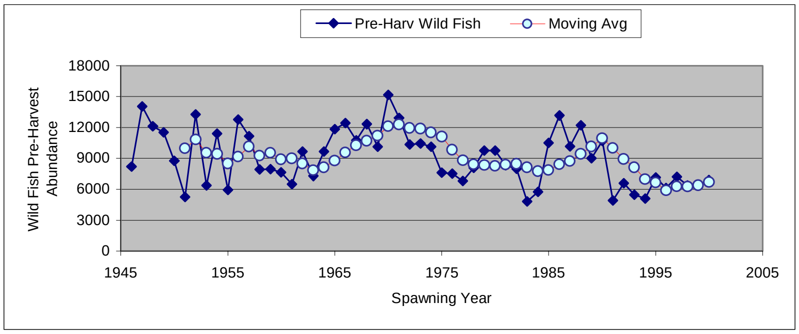
Population: **NFork Winter Sthd**

population:

oring sites: **Winchester Dam**

Method: **Fish Counts at Dam**

l Threshold	227
e Threshold	855
-yr Average	**6692**



Average Distribution of Ages at time of spawning

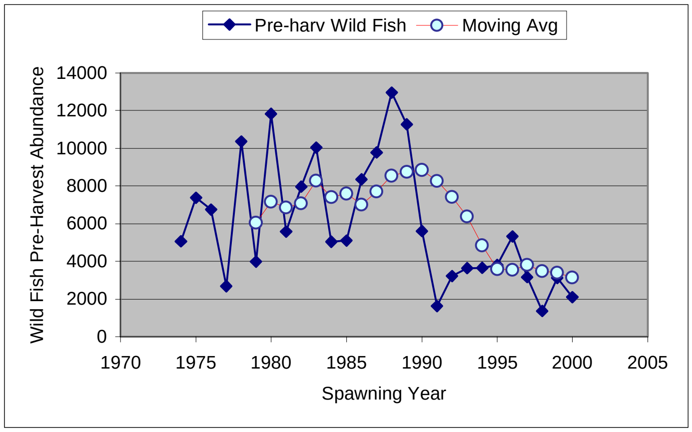
Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.14	0.00	0.00	0.59	0.25	0.03

SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish e-Harv Wild Fi	6-yr Moving Avg
6038	0	6038	8204	
10322	0	10322	14025	
8924	0	8924	12125	
8487	0	8487	11531	
6447	0	6447	8760	
3853	0	3853	5235	9980
9775	0	9775	13281	10826
4686	0	4686	6368	9550
8394	0	8394	11405	9430
4375	0	4375	5944	8499
9394	0	9394	12764	9166
8209	0	8209	11154	10153
5842	0	5842	7938	9262
5862	0	5862	7965	9528
5647	0	5647	7673	8906
4777	0	4777	6490	8997
7115	0	7115	9668	8481
5370	0	5370	7296	7838
7108	0	7108	9658	8125
8714	0	8714	11840	8771
9140	0	9140	12419	9562
7902	0	7902	10736	10269
9074	0	9074	12329	10713
7472	0	7472	10153	11189
11183	0	11183	15194	12112
9504	0	9504	12913	12290
7605	0	7605	10333	11943
7680	0	7680	10435	11893
7456	0	7456	10130	11526
5616	0	5616	7630	11106

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish e-Harv Wild Fi	6-yr Moving Avg
1976	5531	0	5531	7515	9826
1977	5006	0	5006	6801	8807
1978	5968	0	5968	8109	8437
1979	7186	0	7186	9764	8325
1980	7199	0	7199	9781	8267
1981	6140	0	6140	8343	8385
1982	5893	0	5893	8006	8467
1983	3545	0	3545	4816	8136
1984	4221	0	4221	5735	7741
1985	7732	0	7732	10505	7864
1986	9688	0	9688	13163	8428
1987	7501	0	7501	10191	8736
1988	8993	0	8993	12219	9438
1989	6612	0	6612	8984	10133
1990	7854	0	7854	10671	10955
1991	3614	0	3614	4910	10023
1992	4847	0	4847	6585	8927
1993	4017	0	4017	5458	8138
1994	3761	0	3761	5110	6953
1995	5261	0	5261	7149	6647
1996	4503	0	4503	6119	5888
1997	5313	0	5313	7219	6273
1998	4698	0	4698	6384	6240
1999	5829	0	5829	6400	6397
2000	6816	0	6816	6885	6692

Basin:	**Rogue**
Population:	**Upper Rogue SR**
Sub-population:	
Monitoring sites:	**Gold Ray Dam**
Method:	**Counts made at Gold Ray Dam.**

Critical Threshold	258
Viable Threshold	897
Last 6-yr Average	**3142**



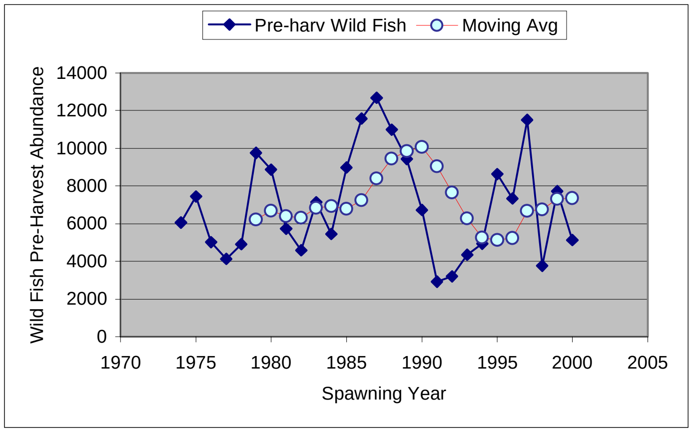
Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.01	0.15	0.54	0.19	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Harvest Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1974	4511	723	5233	0.11	5068	
1975	6573	2020	8593	0.11	7385	
1976	6004	1972	7976	0.11	6746	
1977	2380	0	2380	0.11	2674	
1978	9230	445	9675	0.11	10371	
1979	3542	0	3542	0.11	3980	6037
1980	10530	0	10530	0.11	11831	7165
1981	4977	0	4977	0.11	5592	6866
1982	7080	0	7080	0.11	7955	7067
1983	8939	0	8939	0.11	10044	8296
1984	4484	0	4484	0.11	5038	7407
1985	4543	0	4543	0.11	5104	7594
1986	7430	503	7933	0.11	8348	7014
1987	8710	723	9432	0.11	9786	7713
1988	11534	1427	12960	0.11	12959	8547
1989	10033	148	10181	0.11	11273	8751
1990	4996	1982	6977	0.11	5613	8847
1991	1453	2094	3547	0.11	1633	8269
1992	2876	0	2876	0.11	3231	7416
1993	3598	645	4243	0.01	3638	6391
1994	3620	1878	5498	0.01	3660	4841
1995	3764	2808	6572	0.01	3806	3597
1996	5255	1165	6420	0.01	5314	3547
1997	3127	1640	4767	0.01	3161	3802
1998	1341	175	1516	0.01	1356	3489
1999	3087	29	3116	0.01	3122	3403
2000	2069	0	2069	0.01	2092	3142

Basin:	**Rogue**
Population:	**Upper Rogue WR**
Sub-population:	
Monitoring sites:	**Gold Ray Dam**
Method:	**Counts made at Gold Ray Dam.**

Critical Threshold	235
Viable Threshold	869
Last 6-yr Average	**7352**

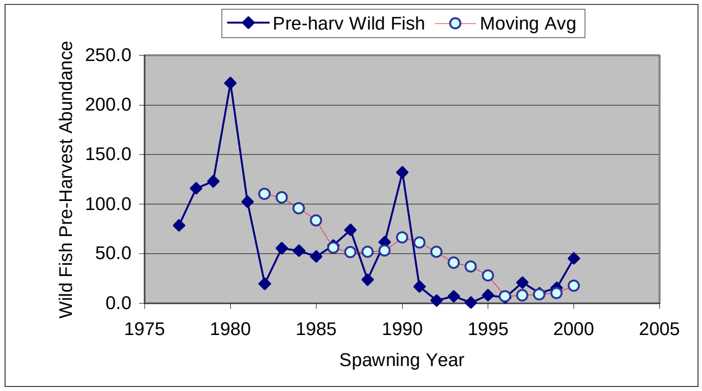


Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.20	0.01	0.14	0.48	0.17	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Harvest Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1974	5570	377	5947	0.08	6054	
1975	6843	249	7092	0.08	7438	
1976	4614	0	4614	0.08	5015	
1977	3800	106	3905	0.08	4130	
1978	4512	0	4512	0.08	4904	
1979	8980	912	9892	0.08	9761	6217
1980	8156	1194	9349	0.08	8865	6686
1981	5271	617	5887	0.08	5729	6401
1982	4213	442	4655	0.08	4579	6328
1983	6573	0	6573	0.08	7145	6831
1984	5009	0	5009	0.08	5445	6921
1985	8255	0	8255	0.08	8973	6789
1986	10643	554	11197	0.08	11569	7240
1987	11663	854	12517	0.08	12677	8398
1988	10103	436	10539	0.08	10982	9465
1989	8675	1028	9703	0.08	9429	9846
1990	6183	343	6526	0.08	6721	10059
1991	2685	417	3103	0.08	2919	9050
1992	2955	174	3129	0.08	3212	7657
1993	4310	401	4711	0.01	4345	6268
1994	4900	174	5074	0.01	4940	5261
1995	8559	662	9220	0.01	8628	5128
1996	7279	0	7279	0.01	7338	5230
1997	11426	341	11767	0.01	11518	6664
1998	3744	0	3744	0.01	3774	6757
1999	7665	0	7665	0.01	7727	7321
2000	5087	0	5087	0.01	5128	7352

Basin:	**Rogue**
Population:	**Middle Rogue SR**
Sub-population:	
Monitoring sites:	**Foots Cr** **Kane Cr**
Method:	**Redd Surveys**



Critical Threshold	5.30
Viable Threshold	9.42
Last 6-yr Average	**17.60**

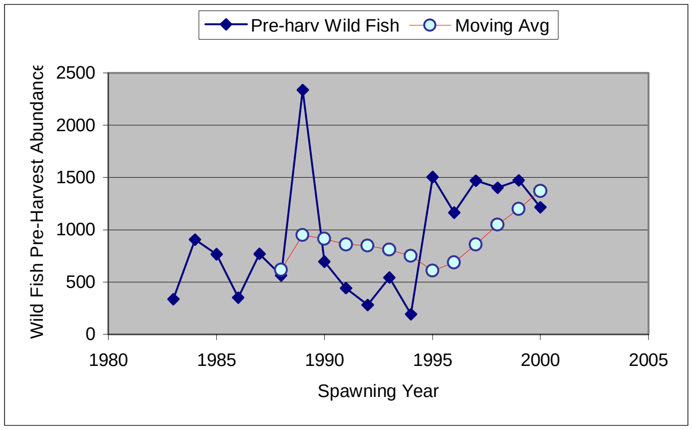
Average Distribution of Ages at time of spawning

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.10	0.01	0.15	0.54	0.19	0.00

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Wild Fish Harv Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1977	72.4	0	72.4	0.08	78.7	
1978	106.8	0	106.8	0.08	116.1	
1979	112.9	0	112.9	0.08	122.8	
1980	204.3	0	204.3	0.08	222.1	
1981	94.0	0	94.0	0.08	102.2	
1982	18.2	0	18.2	0.08	19.8	110.3
1983	51.0	0	51.0	0.08	55.4	106.4
1984	48.8	0	48.8	0.08	53.1	95.9
1985	43.4	0	43.4	0.08	47.1	83.3
1986	53.6	0	53.6	0.08	58.3	56.0
1987	68.2	0	68.2	0.08	74.2	51.3
1988	22.0	0	22.0	0.08	24.0	52.0
1989	56.7	0	56.7	0.08	61.6	53.0
1990	121.3	0	121.3	0.08	131.9	66.2
1991	15.4	0	15.4	0.08	16.7	61.1
1992	2.8	0	2.8	0.08	3.0	51.9
1993	6.5	0	6.5	0.08	7.1	40.7
1994	0.9	0	0.9	0.08	1.0	36.9
1995	7.7	0	7.7	0.08	8.4	28.0
1996	5.8	0	5.8	0.01	5.8	7.0
1997	20.7	0	20.7	0.01	20.8	7.7
1998	10.0	0	10.0	0.01	10.1	8.9
1999	15.4	0	15.4	0.01	15.5	10.3
2000	44.7	0	44.7	0.01	45.0	17.6

Basin:	**Rogue**
Population:	**Applegate WR**
Sub-population:	
Monitoring sites:	**Applgate Dam Trap**
Method:	**Trap counts and ratio of hatchery and wild fish in downstream fishery.**

Critical Threshold	59
Viable Threshold	210
Last 6-yr Average	**1371**



Average Distribution of Ages in return year

Repeat	Age 2	Age 3	Age 4	Age 5	Age 6
0.14	0.00	0.00	0.56	0.26	0.03

Spawning Year	SpwnrsWild	SpwnrsHatc	Effective Tot. Spwnrs	Harvest Rate	Pre- Harv re-harv Wild Fi	6-yr Moving Avg
1983	273	91	364	0.19	336	
1984	733	245	979	0.19	906	
1985	621	208	829	0.19	767	
1986	286	96	382	0.19	353	
1987	624	209	832	0.19	770	
1988	454	152	606	0.19	561	616
1989	1891	632	2523	0.19	2335	949
1990	565	189	754	0.19	697	914
1991	359	120	478	0.19	443	860
1992	229	76	305	0.19	282	848
1993	540	148	687	0.01	545	810
1994	188	51	239	0.01	190	749
1995	1490	407	1898	0.01	1505	610
1996	1153	315	1468	0.01	1164	688
1997	1453	397	1851	0.01	1467	859
1998	1391	380	1771	0.01	1404	1046
1999	1458	399	1857	0.01	1472	1200
2000	1203	329	1532	0.01	1214	1371

Appendix 3. Summary of productivity estimates (Ricker ***a***-values), associated regression statistics (R^2), and proportion of hatchery fish (P_h) for 27 populations of Oregon steelhead by 7-year moving sequences of spawner and recruit data, 1974-95 brood years.

Sequence Years	**Rogue Summers**			**MidRogue Summers**			**Rogue Winters**		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	1.290	0.96	0.10				0.717	0.81	0.05
1975-81	1.191	0.90	0.08				0.822	0.83	0.06
1976-82	1.181	0.90	0.04				1.005	0.77	0.06
1977-83	1.149	0.86	0.01	0.805	0.81	0.00	1.014	0.66	0.06
1978-84	1.241	0.79	0.01	0.565	0.79	0.00	1.323	0.67	0.06
1979-85	1.332	0.79	0.00	0.655	0.82	0.00	1.743	0.95	0.06
1980-86	1.360	0.73	0.01	0.737	0.81	0.00	1.603	0.95	0.05
1981-87	1.819	0.69	0.02	1.300	0.75	0.00	1.741	0.96	0.05
1982-88	1.913	0.84	0.04	0.302	0.05	0.00	1.927	0.93	0.04
1983-89	1.930	0.85	0.04	-0.529	0.00	0.00	2.002	0.89	0.04
1984-90	1.723	0.87	0.08	0.782	0.46	0.00	1.517	0.83	0.05
1985-91	1.071	0.83	0.16	0.136	0.38	0.00	1.306	0.87	0.06
1986-92	0.772	0.92	0.16	0.302	0.54	0.00	1.353	0.94	0.07
1987-93	0.615	0.92	0.18	0.319	0.73	0.00	1.494	0.97	0.08
1988-94	0.433	0.80	0.21	0.801	0.74	0.00	1.560	0.98	0.07
1989-95	0.536	0.69	0.26	1.062	0.80	0.00	1.417	0.92	0.08

Sequence Years	**Applegate**			**N. Umpqua Summers**			**N. Umpqua Winters**		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80				1.237	0.49	0.08	1.726	0.66	0.00
1975-81				1.001	0.18	0.07	2.177	0.65	0.00
1976-82				1.121	0.18	0.07	2.277	0.56	0.00
1977-83				1.268	0.27	0.06	2.133	0.73	0.00
1978-84				1.192	0.20	0.05	2.278	0.80	0.00
1979-85				1.631	0.73	0.05	2.097	0.79	0.00
1980-86				1.904	0.82	0.05	1.725	0.91	0.00
1981-87				2.002	0.87	0.05	1.781	0.80	0.00
1982-88				1.835	0.84	0.07	1.828	0.83	0.00
1983-89	0.367	0.60	0.25	1.365	0.76	0.09	1.641	0.75	0.00
1984-90	0.242	0.56	0.25	0.926	0.74	0.10	1.384	0.57	0.00
1985-91	0.484	0.55	0.25	0.718	0.77	0.12	0.811	0.54	0.00
1986-92	0.670	0.60	0.25	0.923	0.88	0.12	0.820	0.69	0.00
1987-93	0.844	0.59	0.25	1.064	0.93	0.12	1.179	0.94	0.00
1988-94	1.251	0.70	0.24	1.359	0.96	0.11	1.152	0.97	0.00
1989-95	1.487	0.86	0.24	1.364	0.86	0.09			

Appendix 3. (Continued)

Sequence Years	Salmonberry			Calapooia			Lower S. Santiam		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	0.124	0.30	0.00						
1975-81	0.028	0.25	0.00						
1976-82	1.557	0.51	0.00						
1977-83	2.069	0.81	0.00						
1978-84	1.983	0.82	0.00						
1979-85	1.715	0.73	0.00						
1980-86	1.825	0.91	0.00	1.912	0.86	0.00			
1981-87	1.776	0.94	0.00	2.033	0.87	0.00			
1982-88	1.695	0.93	0.00	1.262	0.25	0.00			
1983-89	1.573	0.78	0.00	-0.142	0.04	0.00	0.197	0.17	0.48
1984-90	1.115	0.76	0.00	-0.317	0.06	0.00	0.322	0.21	0.44
1985-91	0.839	0.73	0.00	-0.643	0.03	0.00	0.175	0.06	0.35
1986-92	0.776	0.71	0.00	-0.898	0.01	0.00	-1.232	0.01	0.26
1987-93	0.347	0.66	0.00	0.064	0.24	0.00	-0.438	0.01	0.17
1988-94	0.054	0.21	0.00	0.781	0.49	0.00	-0.064	0.08	0.09
1989-95				1.034	0.44	0.00	-0.182	0.20	0.04
1990-96				1.277	0.60	0.00	0.451	0.52	0.01

Sequence Years	Upper S. Santiam			N. Santiam			Molalla		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	0.400	0.22	0.00						
1975-81	0.645	0.28	0.00						
1976-82	0.776	0.41	0.06						
1977-83	0.606	0.53	0.11						
1978-84	0.307	0.64	0.20						
1979-85	0.427	0.67	0.29						
1980-86	0.406	0.60	0.38				0.735	0.75	0.46
1981-87	0.122	0.43	0.46				0.473	0.29	0.46
1982-88	-0.052	0.41	0.51				0.701	0.45	0.46
1983-89	-0.110	0.42	0.48	-0.146	0.06	0.15	0.010	0.11	0.46
1984-90	-0.376	0.35	0.44	-0.384	0.02	0.15	-0.704	0.01	0.46
1985-91	0.340	0.77	0.35	-1.121	0.06	0.15	-1.278	0.02	0.46
1986-92	0.159	0.57	0.26	-1.192	0.03	0.15	-1.808	0.11	0.43
1987-93	0.268	0.55	0.17	-0.416	0.08	0.15	-0.593	0.14	0.40
1988-94	0.418	0.61	0.09	0.030	0.20	0.15	-0.513	0.18	0.36
1989-95	1.805	0.84	0.04	0.984	0.56	0.14	0.040	0.42	0.33
1990-96	1.745	0.89	0.01	1.328	0.68	0.14	0.606	0.47	0.30

Appendix 3. (Continued)

Sequence Years	Clackamas			Sandy			Warm Springs		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	1.559	0.84	0.21						
1975-81	1.465	0.81	0.26						
1976-82	1.461	0.82	0.28						
1977-83	1.262	0.85	0.27						
1978-84	1.306	0.89	0.26	0.439	0.53	0.50			
1979-85	1.181	0.83	0.22	0.308	0.33	0.47			
1980-86	1.114	0.75	0.19	0.568	0.47	0.46	1.630	0.70	0.00
1981-87	0.891	0.46	0.18	1.302	0.46	0.49	1.388	0.44	0.00
1982-88	1.411	0.52	0.16	*0.534*		0.48	1.549	0.71	0.00
1983-89	1.257	0.47	0.16	*-0.615*		0.50	1.311	0.55	0.00
1984-90	0.969	0.37	0.20	*-1.142*		0.49	0.911	0.48	0.00
1985-91	0.221	0.35	0.24	-0.602	0.03	0.51	-0.232	0.15	0.00
1986-92	1.049	0.41	0.26	-1.105	0.01	0.54	-0.102	0.41	0.00
1987-93	0.587	0.27	0.26	-0.760	0.18	0.56	0.052	0.58	0.00
1988-94	0.078	0.16	0.25	-0.536	0.37	0.55			
1989-95	0.636	0.36	0.26	-0.304	0.53	0.55			

Sequence Years	Deschutes			Lower NFk. John Day			Upper NFk John Day		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80									
1975-81									
1976-82				3.162	0.70	0.00			
1977-83				2.896	0.69	0.00	1.207	0.14	0.00
1978-84	1.464	0.94	0.33	2.368	0.46	0.00	1.631	0.35	0.00
1979-85	1.511	0.96	0.32	2.466	0.80	0.00	2.282	0.74	0.00
1980-86	1.377	0.94	0.32	2.091	0.84	0.00	2.676	0.93	0.00
1981-87	1.300	0.93	0.35	2.016	0.88	0.00	2.796	0.94	0.00
1982-88	1.405	0.78	0.38	1.365	0.80	0.00	2.152	0.76	0.00
1983-89	-0.993	0.04	0.41	0.841	0.82	0.00	1.439	0.59	0.00
1984-90	-1.839	0.06	0.43	0.511	0.95	0.00	2.049	0.73	0.00
1985-91	-1.285	0.04	0.42	0.489	0.95	0.00	2.701	0.75	0.00
1986-92	-1.204	0.10	0.44	0.444	0.92	0.00	2.687	0.75	0.00
1987-93	-0.393	0.48	0.50	0.709	0.74	0.00	2.351	0.61	0.00
1988-94				1.407	0.82	0.00	2.736	0.64	0.00
1989-95									

Appendix 3. (Continued)

Sequence Years	Middle Fk. John Day			South Fk. John Day			Lower John Day		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	1.171	0.83	0.00	1.663	0.94	0.00	3.470	0.90	0.00
1975-81	1.328	0.73	0.00	1.809	0.92	0.00	3.581	0.90	0.00
1976-82	1.621	0.78	0.00	2.000	0.76	0.00	3.816	0.91	0.00
1977-83	1.832	0.79	0.00	1.713	0.65	0.00	3.878	0.90	0.00
1978-84	2.050	0.73	0.00	1.391	0.46	0.00	3.635	0.86	0.00
1979-85	1.888	0.62	0.00	1.930	0.79	0.00	3.467	0.97	0.00
1980-86	2.053	0.90	0.00	2.258	0.81	0.00	2.607	0.83	0.00
1981-87	2.193	0.94	0.00	2.416	0.89	0.00	2.076	0.81	0.00
1982-88	2.129	0.94	0.00	2.431	0.88	0.00	2.110	0.84	0.00
1983-89	1.825	0.80	0.00	1.289	0.75	0.00	1.142	0.62	0.00
1984-90	1.066	0.63	0.00	0.842	0.79	0.00	-0.054	0.36	0.00
1985-91	-0.090	0.12	0.00	0.313	0.82	0.00	-0.721	0.39	0.00
1986-92	-0.237	0.08	0.00	0.094	0.66	0.00	-0.702	0.51	0.00
1987-93	-0.220	0.10	0.00	-0.089	0.57	0.00	-0.574	0.59	0.00
1988-94	-0.111	0.24	0.00	-0.247	0.29	0.00	0.085	0.41	0.00
1989-95									

Sequence Years	Upper John Day			Umatilla			Upper Grande Ronde		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	1.858	0.86	0.00	0.606	0.15	0.00	1.419	0.04	0.00
1975-81	2.239	0.86	0.00	0.444	0.09	0.00	2.447	0.21	0.00
1976-82	2.394	0.77	0.00	1.384	0.45	0.00	2.946	0.26	0.00
1977-83	2.436	0.72	0.00	1.930	0.68	0.00	3.579	0.64	0.00
1978-84	2.222	0.45	0.00	1.930	0.68	0.00	3.937	0.90	0.00
1979-85	2.407	0.80	0.00	2.333	0.96	0.00	2.824	0.64	0.00
1980-86	2.025	0.84	0.00	2.244	0.96	0.00	2.325	0.55	0.00
1981-87	2.117	0.91	0.00	2.327	0.94	0.00	2.187	0.53	0.00
1982-88	2.017	0.91	0.00	2.270	0.98	0.00	1.327	0.48	0.02
1983-89	1.362	0.74	0.00	2.200	0.94	0.01	0.148	0.80	0.03
1984-90	0.691	0.57	0.00	1.663	0.75	0.03	0.028	0.88	0.05
1985-91	-0.301	0.37	0.00	-0.024	0.15	0.06	0.151	0.84	0.08
1986-92	-0.594	0.11	0.00	0.139	0.60	0.11	0.735	0.66	0.12
1987-93	-0.475	0.16	0.00	0.213	0.63	0.14	0.718	0.65	0.15
1988-94	-0.473	0.17	0.00	0.114	0.52	0.19			

Appendix 3.(Continued)

Sequence Years	Lower Grande Ronde			Joseph			Imnaha		
	a	R^2	P_h	***a***	R^2	P_h	***a***	R^2	P_h
1974-80	1.178	3.7	0.00	1.966	0.26	0.00	1.478	0.46	0.00
1975-81	1.245	3.6	0.00	1.968	0.16	0.00	1.644	0.44	0.00
1976-82	1.425	3.3	0.00	2.025	0.17	0.00	1.735	0.38	0.00
1977-83	1.593	3.1	0.00	2.282	0.23	0.00	1.583	0.21	0.00
1978-84	1.724	2.9	0.00	2.716	0.52	0.00	1.995	0.39	0.00
1979-85	1.648	3.3	0.00	2.588	0.87	0.00	2.176	0.66	0.00
1980-86	1.397	4.1	0.00	2.300	0.98	0.00	2.565	0.92	0.00
1981-87	1.441	3.7	0.00	2.312	0.98	0.00	2.440	0.94	0.03
1982-88	1.026	4.6	0.02	2.296	0.98	0.00	1.859	0.75	0.06
1983-89	0.486	7.7	0.04	2.359	0.96	0.00	1.466	0.69	0.09
1984-90	0.058	17.4	0.06	2.130	0.87	0.00	1.188	0.66	0.11
1985-91	-0.018	18.0	0.09	1.082	0.79	0.00	0.195	0.42	0.14
1986-92	0.034	10.1	0.11	1.172	0.89	0.00	0.301	0.63	0.17
1987-93	0.191	7.2	0.13	1.196	0.87	0.00	0.336	0.65	0.20
1988-94							0.275	0.62	0.20
1989-95									